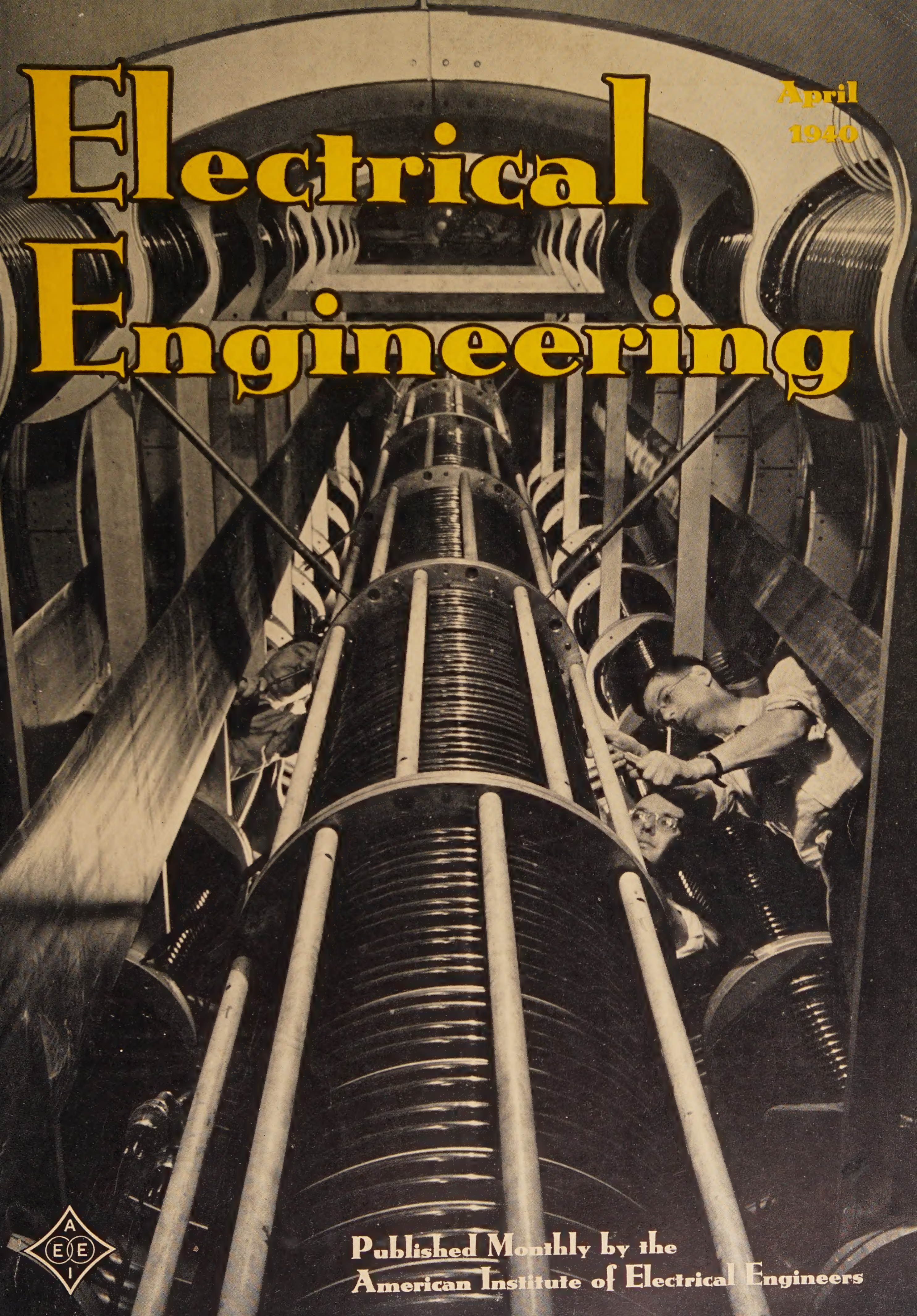
Electrical Engineering

April
1940



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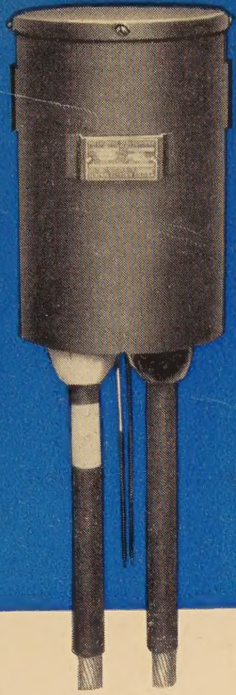
You Get Top-Grade Metering Accuracy with

This NEW Outdoor Current Transformer



Type JW-6
5000 volts

HIGH accuracy all the way down to five per cent of the rating—that's one of the important features of this new metering transformer. And its excellent performance in this respect is clearly illustrated by the curves at the right. Just study for a moment what excellent accuracy Type JW-6 provides. Then consider what this means to you in terms of better metering—assurance of transformer accuracy that meets the highest specifications: ¼X, ¼Y, ¼Z.

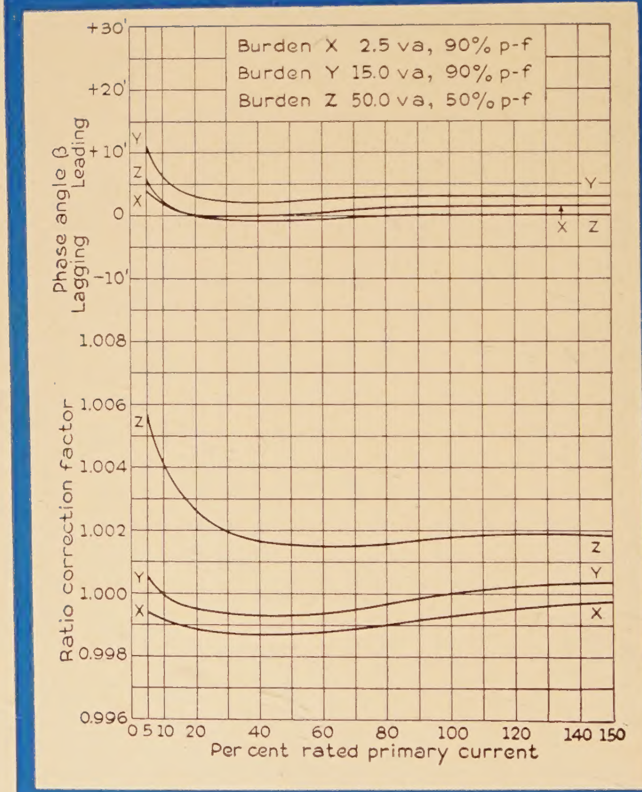
AND BETTER INSULATION

Along with the high accuracy, Type JW-6 offers the advantages of insulation that is designed to withstand a 60-kv full-wave impulse test (2.2-inch test gap). This means that when you use these transformers, you're lining up your apparatus to meet the standard specifications set up by the ASA for insulation for this class of service.

OTHER ADVANTAGES

Besides high accuracy and excellent insulation, Type JW-6 offers the added advantages of a welded-steel tank with mounting brackets welded to the case. Flexible leads, and secondary bushings that can be replaced by conduit connections, increase the ease of installation.

For a complete description of the new Type JW-6, call the nearest G-E office or write for Bulletin GEA-3357. General Electric, Schenectady, N. Y.



Ratio- and phase-angle characteristics

The outstanding accuracy of Type JW-6—particularly at the lower values—is obtained by means of the Wilson compensation scheme, an exclusive G-E feature

GENERAL ELECTRIC

420-57

Electrical Engineering

Registered U. S. Patent Office

for April 1940—

The Cover: A view inside the "atom smasher" built at East Pittsburgh, Pa., by the Westinghouse Electric and Manufacturing Company and recently given its first public demonstration. The device is housed in a steel pear-shaped tank 30 feet in diameter and 40 feet high atop a small brick building.

Transactions Section *(Follows EE page 176; a preprint of pages 193–256 of the 1940 volume)*

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High Lights • •

Illumination at New York World's Fair. Scheduled for inclusion in the May issue is a comprehensive treatment of the nighttime illumination effects at the New York World's Fair, which opens its 1940 season May 11. Several four-color illustrations will be included as well as descriptions of the spectacular illumination effects achieved and many application diagrams and sketches showing how the various light sources are applied. The use of several new light sources previously found only in the laboratories will be described and illustrated.

Railroad Motive Power. Demands for higher scheduled speeds and for increasingly drastic operating economies have led to many recent developments in railroad motive power. The trends of these developments are traced in this issue by the electrical engineer of an eastern road who concludes: "It may be expected that advances will continue and that with further development in other railroad facilities the railroads will continue to serve as the country's most important transportation agency" (*pages 141–8*).

Urban Transportation. Statistics indicate some of the difficulties that would be involved in providing sufficient highways in the city of the future so that all passenger transportation might be by means of private automobiles. Through many developments the public transportation industry is endeavoring to meet the demand for improved urban transportation and to make this inherently more economical means of transportation more attractive (*pages 149–51*).

Letters to the Editor. Further consideration of membership participation in Institute elections and of currents and voltages of a three-phase unbalanced load, previously discussed in the "Letters" columns, and a comment on the new indirect luminaire for drafting-room illumination described in the February issue, pages 68–9, are included in this month's "Letters to the Editor" (*pages 166–8*).

Educational Trends. Data accumulated by the ECPD committee on engineering schools in the course of its accrediting program formed the source of a report on "Present Status and Trends of Engineering Education in the United States", prepared by Dugald C. Jackson (A'87, F'12) and published by the committee in 1939, from which the substance of the chapter on "Trends" is presented (*pages 152–6*).

Wave Shape. Mercury-arc rectifiers draw distorted currents from the a-c supply system, which in turn cause distortion in the voltage wave; reductions may be effected by increasing the number of phases. Telephone interference of one large installation was reduced by using phase-shifting transformers to increase the number of phases to 60 (*Transactions pages 218–26*).

Rectifiers. Rapidly expanding mechanization of coal mining has increased the need for readily movable underground substation equipment, for which the ignitor-type of mercury-arc rectifier is well adapted because it may be used advantageously at voltages as low as 275 volts (*Transactions pages 242–4*).

Voltage Regulation. Special designs of three- and four-winding transformers with synchronous condensers have been used to solve the problem of maintaining reasonably constant voltage levels in a large interconnected network having many load and generating points (*Transactions pages 212–17*).

Lightning Investigation. A co-operative investigation of the effect of lightning on transmission lines has produced data on the magnitude and distribution of current in tower members, overhead ground wires, conductors, and counterpoise wires; the average stroke current appeared to be 30,000 amperes (*Transactions pages 227–34*).

Arc-Furnace Loads. The violent fluctuations and low power factor of the load of electric arc furnaces may result in serious voltage flicker, especially if the load is served from a long transmission line; one particularly difficult problem was solved by installation of a synchronous condenser (*Transactions pages 234–42*).

Oscillograph Light Source. The intense brilliance of the capillary mercury lamps makes it a highly desirable light source for use with oscillographs and enables many records to be made on bromide paper, which is cheaper than film and easier to handle (*pages 157–9*).

Vibrator Inverter. A new type of vibrator inverter for supplying small a-c loads from low-voltage d-c sources opens the vibrating contacts only when the current through them is zero, thus obtaining minimum wear and freedom from spark interference (*Transactions pages 245–8*).

Television System. The Scophony system, which has set the pace for large-screen television in England, makes it possible to modulate a beam of light from an independent source and to project it directly onto a screen to form a large picture (*page 151*).

Radio Interference. Man-made radio noises may be reduced by application at the source of the appropriate one of the three basic methods of control: consideration in design, use of low-impedance shunt filters, or use of high-impedance series filters (*Transactions pages 193–201*).

Electrical Units. Some of the more important projects for securing greater uniformity in electrical units in international use are discussed, with the background of the proposed changes, by an author associated with the National Bureau of Standards (*pages 160–3*).

Circuit Breaker. A new air circuit breaker for 5,000-volt service extinguishes the arc by magnetically forcing it into an interleaving chute in which an ever-increasing cooling effect is encountered (*Transactions pages 202–12*).

Well Drilling. Over-all performance of oil-well drilling rigs may be improved by the use of electrical rather than mechanical drive; the variable-voltage equipment is driven by an internal-combustion engine (*Transactions pages 248–56*).

Summer Convention. Appointment of the general committee for the 1940 summer convention, to be held at Swampscott, Mass., June 24–28, is announced with other preliminary plans in the Institute Activities section (*page 169*).

Turbine-Blade Research. An experimental high-pressure steam turbine enables engineers to "look" inside the turbine while it is running and observe the vibration of the blades directly (*page 159*).

Coming Soon. Among special articles and technical papers now undergoing preparation for early publication are: An article on "this culture" in engineering by AIEE Past President J. C. Parker; an article discussing the question "Should engineers join a union?" by AIEE Presidential Nominee R. W. Sorensen; an article describing the new high-voltage laboratory of the United States Bureau of Standards by F. B. Silsbee (M'26); an article summarizing the results of a survey of noise in various types of rooms at different locations by D. F. Seacord (A'18); a paper on an unstable nonlinear circuit by C. M. Summers (A'30); a paper on the causes of corrosion of fine copper wires carrying a potential by H. N. Stephens and G. B. Gehrenbeck; a paper on load-rating theory for multichannel amplifiers by B. D. Holbrook (A'39) and J. T. Dixon (A'39); a paper describing some recent improvements in impulse voltage testing by C. M. Foust (M'31) and N. Rohats (A'36); a paper on protector tubes for power systems by H. A. Peterson (A'35), W. J. Rudge, Jr. (M'39), A. C. Monteith (A'25), and L. R. Ludwig (A'28); a paper on the theory and design of NEMA resistors for motor starting and speed control by G. C. Armstrong (A'39); and a paper on power supply for resistance-welding machines by the subcommittee on power supply for welding operations of the AIEE committee on electric welding.

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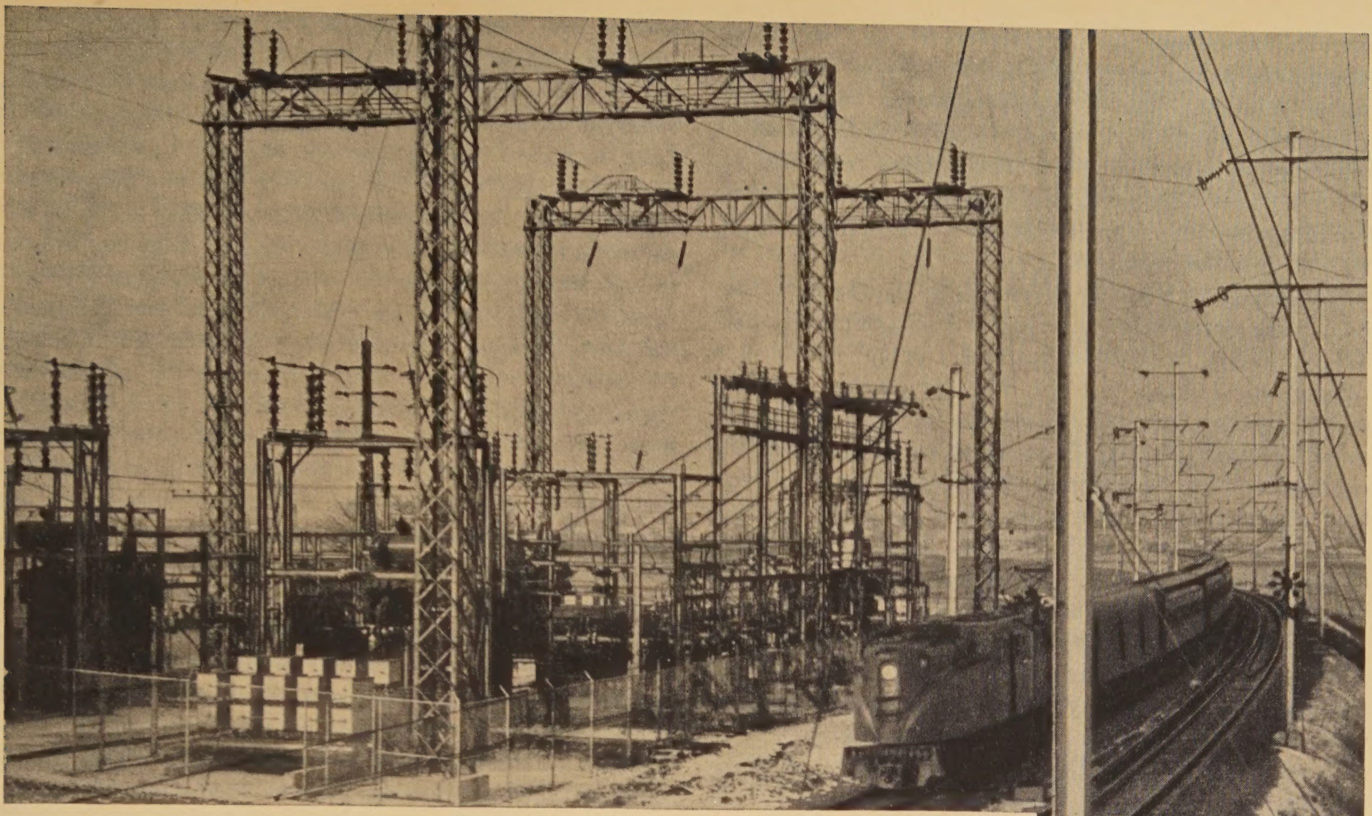


Trends in Railroad Motive Power

Growing demands for higher scheduled speeds and for increasingly drastic operating economies have stimulated many of the recent advances in railroad motive power

SIDNEY WITHINGTON
FELLOW AIEE

AMONG the important problems met in railroad operation today are those presented by the demand for increasingly high speeds in both passenger and freight operation. These involve increased power capacity and refinements in design, construction, and maintenance of locomotives. Braking is of especial importance in high-speed operation and is being developed to a noteworthy degree. Some of the problems may be visualized when it is considered that a train of a given weight has nearly three times the kinetic energy at 100 miles per hour that it has at 60 miles per hour. These items obviously involve added capital and operating expense, and railroad managements must decide carefully just where to draw the line in meeting the demands for speed—safety, of course, always being the primary and fundamental consideration. It may be said that, in general, speed limits are imposed by track and other fixed property rather than by motive-power limitations.

The light, modern train, though operating at increasingly higher speeds, often does not require the concentration of locomotive horsepower capacity that the long, heavy train of older cars requires. The motive-power problems are thus somewhat different as between these two classes of service, though there is no sharp dividing line, especially as horsepower may be advantageously used to attain not only high top speeds, but rapid acceleration—equally or more important in meeting schedules now demanded, particularly when runs are short and slowdowns frequent.

There are three main classifications in the railroad operating field which may apply under present conditions in discussions of developments in motive power: (1) main-line passenger service; (2) main-line freight service; (3) yard-switching and local freight service. In each of these three classes of service a number of developments have taken place during the past few years involving various forms of motive power.

Types of Locomotives

The demands of rail transport service have led to certain developments in various types of motive power. A comparison by a single quantity without qualification of the horsepower of locomotives of diverse types may be quite misleading, for the characteristics are rather fundamentally different among the various types. In a steam locomo-

Essential substance of AIEE paper number 40-29 presented at the AIEE winter convention, New York, N. Y., January 22, 1940.

SIDNEY WITHINGTON is electrical engineer, New York, New Haven and Hartford Railroad Company, New Haven, Conn.

tive, the horsepower rises with the speed and is maximum at only one point; above and below this speed the horsepower falls off. The Diesel locomotive, whether provided with mechanical or electric drive, is essentially a uniform-horsepower device. The engine operates at generally uniform speed and may supply power up to its full rated capacity, regardless of the locomotive speed, but with no overload capacity.

The horsepower rating of an electric locomotive may be a particularly vague quantity unless carefully defined. The limitation of the power of the traction motors is a temperature limitation. The inherent thermal capacity of the motors, however, allows the application of considerable overloads, depending upon the duration of the overload and on the design of the equipment. This overload characteristic, being inherent, is not obtained at a sacrifice of efficiency, weight, or cost. Horsepower ratings of electric locomotives are usually based upon continuous capacity, but overload characteristics often conform to the varying requirements met during a specific run, such as in starting, accelerating after slowdown, or in short grades, and the effective capacity actually available under such conditions is far in excess of the continuous rating.

There has been a great deal of discussion regarding the relative costs of various types of motive power. Such discussion, being based upon the flexible data of horsepower rating, is obviously quite empirical. An endeavor to correlate the more reliable figures, however, indicates roughly that, based upon rated drawbar continuous horsepower capacity, the relative weights per horsepower for road engines are: standard steam, including tender, 190–220 pounds; Diesel 150–160 pounds; and electric 100–120 pounds. The ratios of cost, also very approximately stated are: standard steam 100 per cent; electric 250 per cent; and Diesel 330 per cent. On account of the more generous short-time overload characteristics of electric equipment (as compared with steam or Diesel) which, as indicated, may satisfactorily match service requirements, the figure for electric locomotives as compared with steam may be materially reduced in specific instances. If, for instance, 90 per cent overload can be usefully employed for short periods in a given service, the figure of 250 per cent for the relative cost of electric locomotives would be reduced to the order perhaps of 130 per cent and the weight per horsepower to perhaps 55–65 pounds. The various other types of locomotives, which are generally somewhat experimental, cannot be considered in a comparison even as rough and approximate as this. It is quite possible that the practice of manufacturing Diesel locomotives for stock from standard designs may become common, reducing materially the cost through quantity production. Indeed this has been done to a slight extent with Diesel switchers.

Steam Motive Power

The conventional or standard type of steam locomotive has been subject to many important improvements in recent years, while still retaining its fundamental arrangement (horizontal boiler, horizontal cylinders with connecting rods, and coupled drivers). Boiler pressures and superheat have been increased, feed-water heaters, mechanical stokers, and many other devices have been added (many of these taken from central-station practice) which have increased the locomotive efficiency and capacity and practicable length of locomotive runs to a noteworthy degree. The thermal efficiency is now roughly between seven and eight per cent under normal load conditions, though much less than this when load and speed conditions are not favorable, as is often the case, and also much less when the locomotive operation is not in skilled hands. Increasing weights of trains, demanding higher drawbar capacity, together with increasing speeds required of equipment, mean increased horsepower which calls for larger boilers and grate areas, and many other improvements.

One of the greatest increases in economy in the operation of steam locomotives lies in increasing the length of runs. Twenty-five years ago few steam locomotives ran more than 100 miles without being taken off and sent to the engine house for inspection, fire cleaning, boiler washing, etc., whereas now runs of 500 to 800 miles are not uncommon when service conditions permit, though occasional stops are necessary for fuel and water in spite of considerable increase in the size of tenders. The direct operating savings are large, and the added annual mileage of the equipment is advantageous from many viewpoints.

Several designs of steam-locomotive boilers that are radically different from the standard equipment have been tried with greater or less success. A number of extra-high-pressure units have been tried with pressures up to 1,700 pounds. Such arrangements may be of the double-pressure type, the high-pressure system being a closed cycle from which the heat is transferred to the secondary-pressure steam supplied to the cylinders which are usually of standard design. This arrangement has the advantage of reducing boiler-feed-water-treatment problems where high pressure is involved.

The so-called "Velox" boiler has been adapted experimentally for locomotives abroad, but has not yet been tried in the United States. This is a boiler utilizing combustion under pressure in a small space with consequent high rate of combustion and high velocity of gases and highly efficient heat exchange for the generation of steam. Capacities of 70,000 pounds per hour are said to be obtained with a single boiler of this type at very high efficiency.

Somewhat related to the development abroad of the Velox boiler are recent developments in gas turbines, also in the developmental stage, but with interesting possibilities. The gas turbine is of two types, the "explosion" or constant-volume type, and the continuous-combustion or constant-pressure type; a turbine of the latter type is being applied in Switzerland to a locomotive. The device includes a compressor which provides air for both combustion and cooling. This air enters the combustion chamber and cooling jackets at a pressure of 20 to 30 pounds. The products of combustion and the cooling air subsequently mix and enter the turbine together. The compressor, mounted on the shaft with the turbine, absorbs a large share of the power developed, but the effi-

ciency of the turbine is so high that the net efficiency of the set, deducting the power used by the compressor, is not unsatisfactory. This locomotive has a net drawbar capacity of 1,900 horsepower with electric transmission of the usual type.

A number of steam-turbine locomotives have been built, especially in Europe, both with mechanical drive and with electric drive. Turbine locomotives have an obvious advantage in that they avoid reciprocating parts, but where mechanical drive is employed they are faced with certain limitations, such as the fact that their efficiency is maximum at but one speed. Furthermore, since the turbine is not reversible, either gears, a separate turbine, or reversing blades on the main turbine are required for reversing. In spite of these limitations, however, a number of turbine locomotives, both condensing and noncondensing, are in satisfactory operation abroad with direct mechanical drives, and it is quite possible that they may be generally developed.

One of the most interesting recent steam locomotives is the high-pressure turboelectric locomotive designed for transcontinental use in the United States, described at length in the October 1939 issue of ELECTRICAL ENGINEERING (pages 407–13). The operating characteristics of this locomotive are in certain respects somewhat similar to those of the six-engine Diesel-electric locomotive referred to hereinafter, and comparisons will be exceedingly interesting and valuable after operating experience with both types has been accumulated.

Steam rail cars have been tried from time to time, both in the United States and abroad, but in spite of certain apparent advantages have never been applied in large numbers on account of various limitations. Cars for such service are now generally propelled by internal-combustion engines, as indicated later.

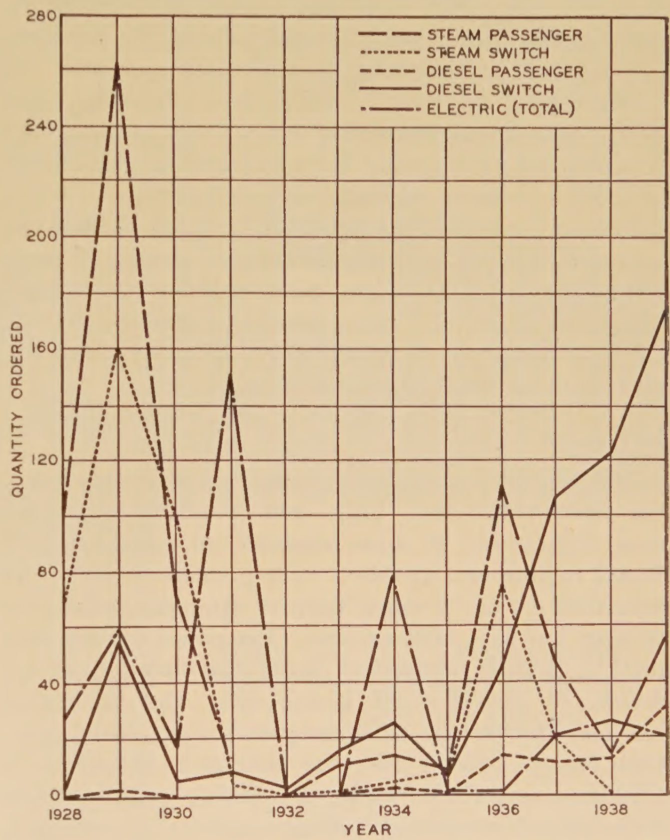
Diesel Motive Power

The Diesel engine has many obvious advantages in fuel efficiency and in operation, and has thus found considerable application in the railroad field, especially in handling relatively lightweight high-speed streamlined passenger trains on long runs through noncongested territory, and in yard switching and local freight-transfer operation.

The horsepower of the Diesel engine, as applied to rail service, is limited by considerations of practicable engine speed, right-of-way clearance requirements, and other factors. Engines now built have from 4 cylinders usually arranged vertically over the driving shaft, to 12 or 16 cylinders arranged either vertically or in "V" design. A novel 5-cylinder two-cycle engine with opposed cylinders has been developed with a capacity of 750 horsepower. Two pistons, vertically arranged in each cylinder, operate in opposite directions, a common combustion space serving both. Two crank shafts thus are employed, one above and the other beneath the cylinder, either geared or belt connected. This arrangement gives very satisfactory dynamic balance.

The two-stroke and four-stroke cycles are both largely used, and supercharging is common. The capacity of single prime-mover units normally varies from about 300 to 1,000 horsepower, though in some instances 1,200 or even 2,000 horsepower is used. When locomotives of larger capacity are required, two or more engines are employed, each usually driving its own generator, and all arranged for multiple-unit control. Engine speeds are usually limited to a maximum of about 1,200 rpm, though the speed most commonly employed with the larger engine units is about 750 rpm. The thermal efficiency of the Diesel engine is of the order of 25 or 30 per cent.

Electric drive in the United States is most common,



Number of locomotives of various types ordered by United States railroads, 1928–39. Separate curves are given for steam and Diesel switch and passenger locomotives, but the curve for electric locomotives includes both types

though elsewhere various forms of mechanical or hydraulic drive are also used, especially in capacities up to 400 or 500 horsepower.

High-Speed Passenger Trains

There is a tendency in the construction of modern cars toward increasing luxury by providing improved lighting, ventilation, air-conditioning, and other conveniences, which involves considerable auxiliary equipment. Recent installations indicate a tendency toward three-phase 220-volt, 60-cycle power for auxiliary service. This power, usually fed through the train from the train-service engine room at the head end, operates air-conditioning, lighting, battery-charging, ventilation blowers, refrigeration, radios, telephones, and, through suitable transformers, various

appliances. Even train heating is sometimes electric.

Traction-power requirements, as already indicated, are obviously increasing with the increased length and weight of trains. As has been said, the capacity of an individual Diesel engine thus far is limited by considerations of space and engine speed, so that when additional capacity is required, the solution of the problem lies in adding engine units. Thus a modern train of 11 cars weighing somewhat over 800 tons, is hauled by a locomotive containing as many as six Diesel engines, each rated at 900 or 1,000 horsepower, and each driving its own generator and traction motors. Such a locomotive comprises three cabs, each with two engine units, and is rated up to 6,000 primary engine horsepower. In such a train the auxiliary power may be quite separate from the main supply.

The capital involved in the modern streamline train hauled by a Diesel locomotive is relatively so large that it is necessary to operate the equipment as intensively as possible, making as many revenue miles per year as conditions permit. For this reason the trains of this type are usually assigned to long runs between terminals, sometimes more than 2,000 miles. Such operation requires certain maintenance en route, especially where the time at terminals of necessity is reduced to a minimum in the interest of high annual equipment mileage.

Rail Cars

The operation of single cars, especially on branch lines, has been mentioned. Such cars, requiring relatively small horsepower, in some instances are equipped with Diesel engines and in others with gasoline engines. As indicated, the use of steam has been attempted from time to time, but with little success. The power transmission may be electric, mechanical (using disk clutches), or hydraulic, up to 500 or 600 horsepower. The disk clutch has the disadvantage of interrupted torque during gear-ratio change, though this time element is reduced to a minimum, especially where a separate pneumatically operated and interlocked clutch is employed for each gear set. Hydraulic drive is employed to a large extent abroad, but is little used in the United States, although a form of simple turbine drive with centrifugal pump, successfully developed for highway coaches, may find application in rail cars. The latest development of this type now in use on railroads comprises a triple-stage turbine transmission. This type of drive is adapted for multiple-unit operation without complication and has an average efficiency of 80 per cent for all track speeds between 30 and 100 per cent of full speed.

In rail-car equipment the engine may be installed in a compartment in one end of the car or, more recently, in a horizontal position under the car body, or in the truck itself, thus leaving the entire car body free for revenue purposes. The location in the truck has the advantage of relieving the car body of vibration.

Yard-Switching and Freight Service

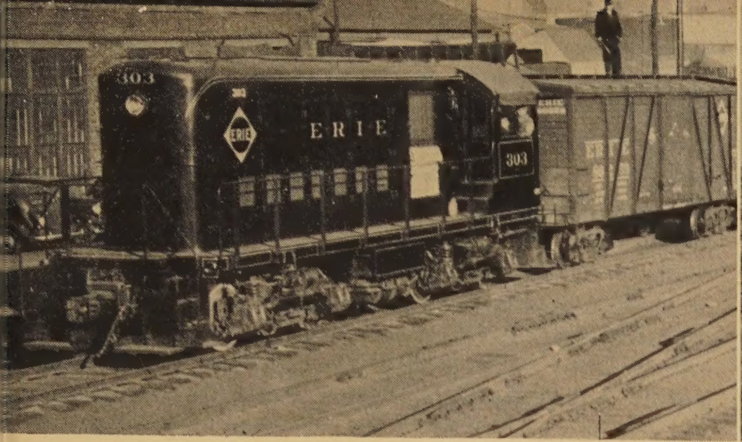
The development of Diesel motive power in freight and yard-switching service has been quite different in some respects from that for passenger service, though the same type of Diesel engines may be employed in both classes of locomotives. The railroads of the United States are concerned, as has been said, with the operation of heavier freight trains at higher speeds. This means a concentration of horsepower that would make Diesel locomotives quite out of the question for main-line through freight, on account of the capital expense required in the locomotive.

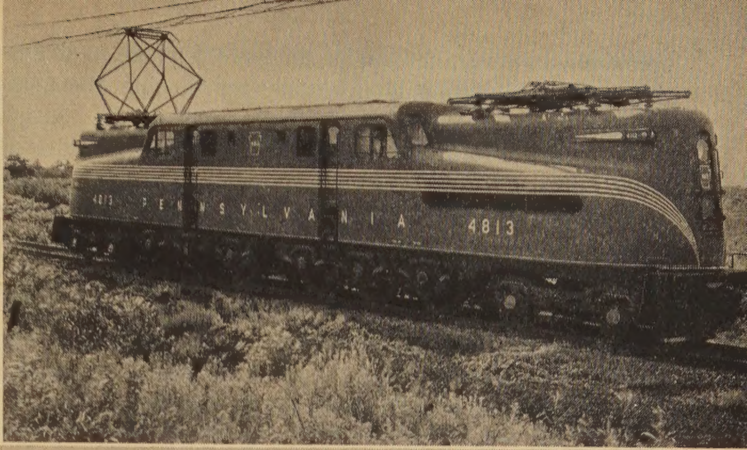
For flat-yard switching the Diesel-locomotive characteristics are so nearly ideal that they are being increasingly employed for such service. As has been said, the flexibility of the power transmission, whether electric or mechanical, permits use of practically full horsepower capacity at low speeds. A large part of the process of flat switching is carried on at low speed, and a Diesel locomotive of relatively low rated horsepower can thus compete favorably in speed of switching cars with a steam locomotive of considerably greater maximum rated horsepower capacity. Under some circumstances the cost differential between a steam switching locomotive and a Diesel of stock size capable of doing the same work may be negligible. All of the weight of the Diesel locomotive can be carried on the driving wheels, and it is not necessary constantly to accelerate a heavy tender in the reciprocating movements that constitute flat switching operations, though there is of course relatively less braking power without the tender. For these reasons and because of high thermal efficiency, high use-factor, and low stand-by losses during waiting periods, the use of Diesel locomotives in flat-yard switching is becoming common. It is probable that Diesel locomotives will find increasing use in switching service except under special conditions, such as locations in the vicinity of coal mines where coal is cheap.

Diesel switching locomotives are usually of capacities of 600 to 900 horsepower, and, more recently, 1,000 horsepower, usually in single-engine units, with electric power transmission between engine and driving wheels.

A development of interest has been a double-reduction gear for the driving motors. Such an arrangement obviously permits installing smaller traction motors operating at higher speeds to deliver equivalent horsepower at low locomotive speeds, than is possible with single-reduction gears, and there is thus some economy in first cost. The limitation in this type of drive lies in the relatively lower top speed of the locomotive as compared with one equipped with single-reduction gears. This is not of importance, however, unless the locomotive is expected to do some road work in connection with the yard switching or to make quick light moves.

While locomotives of 600 to 900 horsepower are eminently satisfactory for ordinary flat-yard switching, a switching locomotive may be required to haul a string of cars from one yard to another several miles away, perhaps stopping to pick up or drop cars en route. In service of this kind, 600 or even 900 horsepower may impose a serious speed restriction on the transfer trip, as compared with a top rating of perhaps 1,500 horsepower available from a steam locomotive with which otherwise the Diesel switcher might compare favorably. The limitations of the Diesel locomotive in this class of service may

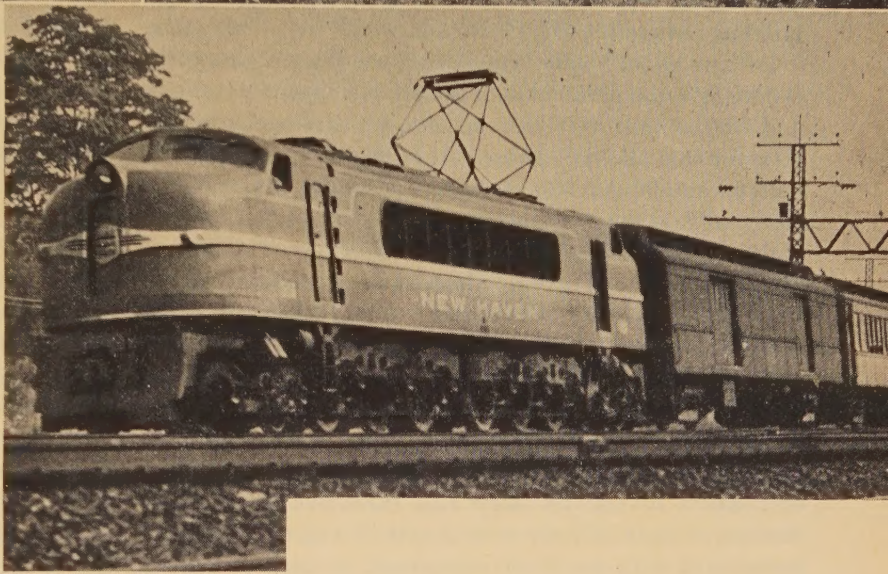




(Above) A 900-horsepower Diesel-electric switcher in action in the Jersey City yards of the Erie Railroad

(Below) Two-unit 4,000-horsepower Diesel-electric locomotive of the Chicago and Northwestern's "400" passenger train

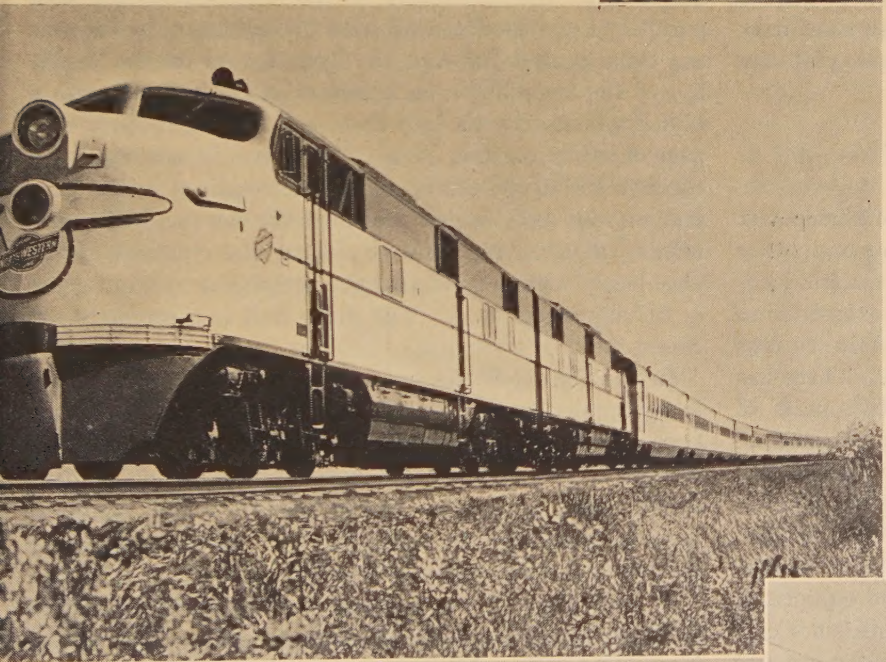
(Bottom) Wide-gauge (63 inches) 4,000-horsepower 3,000-volt d-c passenger locomotive recently built for the Paulista Railways, Brazil

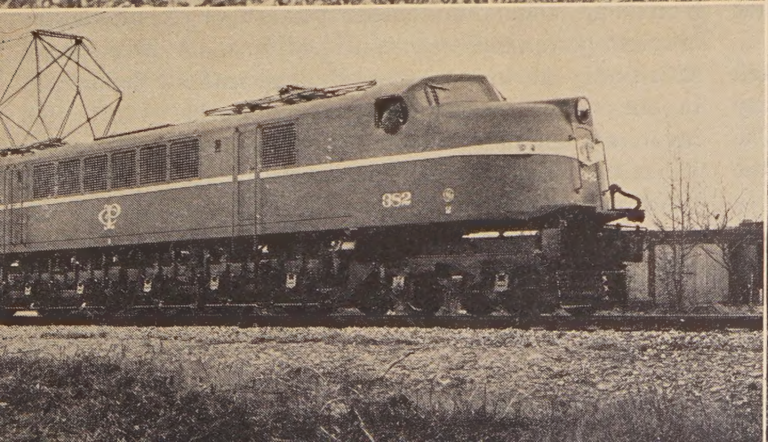


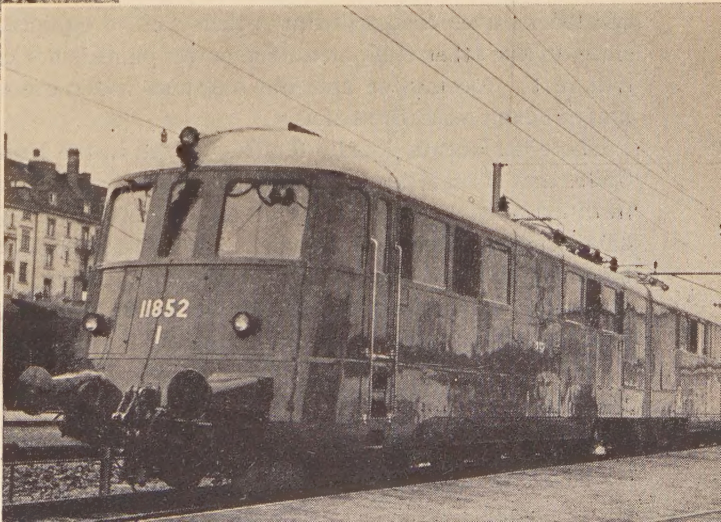
(Top) Type GG1 4,600-horsepower 11,000-volt a-c passenger locomotive of the Pennsylvania Railroad

(Above) New York, New Haven and Hartford 3,600-horsepower 11,000-volt a-c passenger locomotive in action

(Below) A 10,600-horsepower locomotive in use on the St. Gotthard line of the Swiss Federal Railways







be offset, however, because of time saved which in steam-locomotive operation is necessary for turning the locomotive at terminals and for stops to take water. A few railroads have developed yard switchers of capacities of 1,800 to 2,000 horsepower for such service, though it sometimes may be economical to add an extra switcher for such an occasional transfer trip, since multiple-unit control makes unnecessary extra labor.

Some railroads have added storage batteries to the Diesel locomotive equipment in special instances, to supply short-time peak demands and permit relatively lower Diesel power to be installed for normal operation. This arrangement is also of advantage in operation within buildings where the Diesel exhaust would be troublesome.

By and large, it may be said that the Diesel locomotive is making a distinct success at the present time in passenger and freight yard switching because its characteristics are ideal for that class of service. It is also being successfully used in handling certain types of passenger trains, especially on long runs through noncongested territory where high sustained speed is possible. However, in spite of thermal efficiencies several times those of standard steam locomotives, it is not yet entirely established just how the combined cost of fuel, lubrication, repairs, capital charges, etc., will compare over a period of years with such charges for a steam locomotive of modern design hauling a train of the same weight. Since fuel costs vary widely in different localities, the Diesel locomotive may prove economical in one territory and expensive in another. Because of the relatively great length of a three-cab Diesel locomotive with auxiliary equipment, it may present a problem at stub-end terminals where the equipment may occupy a large part of the available terminal platform space.

Electric Motive Power

There is a tendency toward concentration of horsepower and increase of speed in electric locomotives, as with other forms of motive power. Developments in electric locomotives have been made possible by improvements in traction-motor design and construction and in various other details, both mechanical and electrical. There has been some tendency toward single locomotive units of larger capacity, and it is usually still contemplated that two or more units can be readily coupled together for added horsepower concentration and operated as a single multiple-unit locomotive by a single crew. The concentration of power may be thus relatively greater with electric locomotives than with any other class of equipment since, unlike other equipment, the power plant is not carried in the locomotive and the fuel and water are not hauled about with the train.

There has been a definite tendency, both in the United States and abroad, toward individual axle drive and away from coupling the drivers by means of side rods. The chief consideration in all such forms of transmission is the mounting of the motors on the truck frame, reducing to a minimum the unsprung weight on the axles themselves. The only side-rod locomotives recently produced for road service have been in Sweden and Hungary. Slip relays are now usually employed to protect the motors in the event of slipping of individual driving axles. In some cases, weight-shifting devices may be employed to transfer weight from idle axles to driving axles to increase the traction capacity where this may be required, as on grades or in starting.

The most common form of drive in use abroad is the link type, though this has never attained popularity in the United States. In this type of drive the motors are usually mounted above the driving axles and the power transmitted through pinions and gears, located usually outside the driving wheels. The links permit a variable distance between the pinion centers and driving wheels while maintaining torque conditions for driving. The location of the gears outside the driving wheels permits somewhat greater motor length.

The quill type of drive in various forms is common in the United States. In this type the motors are usually mounted above the driving axles, often in pairs, and the gears are generally located inside, between the driving wheels, mounted on quills which connect through springs with the driving wheels; in some cases rubber has been used with success. This quill spring type of drive limits the minimum size of the driving wheels on account of the necessity of maintaining sufficient room for the springs within the wheel centers. In some instances the quill springs are applied to the gears, rather than to the drivers.

An arrangement that has been applied successfully abroad, employs two motors facing each other above each driver with the armatures in line above the axle and parallel to it. Double-reduction driving gears to the axle are thus located between the two motors on the center line of the locomotive, each motor being equipped with a pinion which drives a jack-shaft which in turn operates a gear floating on the axle. The drive is accomplished through sliding blocks or universal couplings in the gear and on the axle, which transmit the torque while permitting the driving axle to follow the vertical spring play freely without affecting the peripheral speed of gears or driving-wheel rims. The drive unit is completely enclosed in oil.

In the United States twin motors have been very generally applied to electric road locomotives of recent years, two pinions thus driving a single gear. Nose-suspended motors in general have not been applied to locomotives of this type, although constituting a common arrangement in Diesel-electric and high-speed locomotives where the power per driving axle is limited.

In some types of locomotive the entire weight is carried on the driving axles, while in others a portion of the weight is on idling axles. The choice depends upon a combination of speed, power, and other considerations. At slow speeds satisfactory tracking may be obtained with all the drivers in one wheelbase without guiding trucks. Since this involves a minimum number of motors and no idle axles, it has the advantage of a minimum first cost. In other cases, as when the horsepower is great even though the maximum speed may be low, guiding or idling axles may not be needed for tracking purposes, but it may be found

economical to load the individual driving axles as much as possible, thus reducing the number of motors, and to carry the excess weight on idling axles. As speed and horsepower increase, tracking characteristics become paramount, and it has been found that best results are obtained by providing a reasonably light load per axle with four-wheel guiding trucks at either end of the locomotive, though some of the high-speed Diesel locomotives do not have guiding trucks. The most common electric-locomotive arrangement in the United States is two idling axles at either end of the cab, with the driving wheels, usually four or six in number, between on articulated trucks. Four driving axles also are not uncommon.

Locomotive frames are usually built up of steel parts, welded, though in the United States steel castings often still are employed. As with other types of locomotives, electric locomotives have been largely streamlined, or at least designed with rounded corners as a sort of compromise, or quasi streamlining. Since the locomotives are usually intended to haul standard coaches and are equipped for operation from either end, the effectiveness of streamlining is suggested rather than real.

In the design of traction motors there has been marked improvement during the past ten years, especially with single-phase motors. This improvement includes brush supports, increased number of poles, commutator design permitting increased peripheral speed, improved insulation, increased efficiency of ventilation, welded steel frames and housings, and numerous other details. Single-phase motors are also equipped with improved control, permitting application of higher voltages at the higher speeds; this produces an increase in horsepower at these higher speeds, a valuable characteristic in meeting the demands of modern railroading.

Forced ventilation is practically universally applied in road locomotives at the present time, and the insulation now used permits temperatures up to 140 degrees centigrade. Other forms of insulation are being developed, and there is little question that generally higher temperatures will be found practicable in the not distant future.

Electric apparatus on the locomotives is usually protected by circuit breakers, though in some instances the trolley-feeder breakers are relied upon for protection in case of trouble on the locomotive. In these cases no circuit breakers are installed on the locomotives, the protection being entirely from the line circuit breakers; in the event of trouble on the locomotive, after the power is cut off from the line, the pantograph is automatically lowered, thus clearing the line.

The motor voltage control on single-phase locomotives is usually effected by taps from the secondary coils of the main transformer, although in some instances abroad, the tap-changes are made on the primary or high-voltage side. Until a few years ago transformers in the United States were air-cooled, although oil-cooled transformers have long been standard in Europe. Recently oil-cooled transformers have been generally applied in the United States and in some instances inert-liquid cooling is used.

In almost all locomotives now constructed, two pantographs are applied per cab. In Europe both pantographs are normally operated together, while in the United States one is usually kept in reserve. Either single or double shoes are operated on locomotives and single shoes generally on multiple-unit cars and certain smaller locomotives. In the United States the pantographs are usually held against the wire by a spring and lowered by air, while abroad the reverse is true. Pantograph pressures vary a great deal. In Europe, pressures of 8 to 12 pounds are employed in single-phase electrification systems when the current collected is relatively small, while in d-c electrification systems of lower voltage and therefore higher current density, pressures may run as high as 26 pounds, which is a maximum. In the United States the pantograph pressure usually ranges between 26 and 35 pounds and does not seem to be a function of the amount of current to be collected.

The use of pantograph lubrication is gaining popularity, carbon often being inserted in recesses in the pantograph shoe, which in the United States may be either a steel stamping or steel with copper wearing strips screwed into it, and in Europe is usually aluminum or an aluminum alloy. It has been found that after the carbon has been applied for a short time the contact wire attains a glassy polish like that of a commutator, and the wear is considerably reduced, both on the contact wire and on the shoe itself.

Electric braking is used considerably abroad, but not very much in the United States, except in operation on long, heavy grades when regenerative braking is employed. Direct-current locomotives are readily adapted for regenerative braking by the addition of a relatively small amount of apparatus. The single-phase commutator motor is adapted to regeneration at line frequencies by means of excitation with alternating current at line frequency, though most of the electric braking on single-phase railroads is rheostatic rather than regenerative. This type of braking has been used to a considerable extent abroad as an auxiliary to the normal train brakes. The current generated may be either alternating (if the excitation is from the line), or direct, the motors being self-exciting. As is well known, the phase converter or straight three-phase equipment is automatically adapted to regenerative braking with little additional equipment, as it operates at speeds approaching synchronous speed regardless of load magnitude or direction.

In the United States train heating with electric locomotives is usually accomplished by means of oil-fired boilers in the locomotives or trailers. Electric boilers of various types are being experimentally tried. In Europe many trains are directly heated by electric heaters supplied from the locomotive bus.

Electrically operated air compressors are normally installed on electric locomotives. These are either single or in duplicate, depending on conditions. In Europe the electric air compressors are often supplemented by mechanical compressors operated from the axle of the locomotive, and the airbrake supply is thus independent of the integrity of power supply—an advantage especially on long descending grades.

Interesting developments have been undertaken abroad experimentally in utilizing power at commercial frequencies with single-phase distribution. This was first tried on a large scale in Hungary in about 1932 with 50-cycle power distribution and phase-converter locomotives, and the system is in successful operation at the present time. A single traction motor, supplied by a rotating phase-converter, drives the locomotives by means of side rods. On the most recently built locomotives in this electrification the phase-converter stator has two main windings, one single-phase connected to the line and the other polyphase connected to the traction motor. The stator windings are arranged to give either three-, four-, or six-phase supply. The rotor has four poles and the exciter and starting motor for the sets are mounted on the main shaft. Four fixed or synchronous locomotive speeds are obtained by combining pole changes on the traction motor with the different phase arrangements available from the converter. Intermediate speeds are obtained by variable resistances in the motor circuit.

Recently the German State Railways have undertaken experiments with similar power-distribution-frequency characteristics, supplying the contact system with power at 20,000 volts and 50 cycles. Various types of locomotives are experimentally operating, including: a phase-converter type with three-phase traction motors; mercury-arc rectifiers with standard series-wound d-c motors; and single-phase series commutator motors utilizing the 50-cycle supply direct.

The German experimental phase-converter locomotive carries four phase converters, each supplying a separate three-phase traction motor driving its own axle. The phase converters have wound rotors and stators, between which there is a free intermediate rotor with d-c excitation, which provides the rotating field necessary for phase conversion. During starting and when running at reduced speeds, the phase converters act as motors. There are three connections: In the first the converters and motors are in series, thus comprising eight traction motors; in the second the converters act alone as motors; and in the third the motors are fed from the stators of the converters. Intermediate speeds are obtained by variable resistance.

On the two rectifier locomotives the speed control is effected by varying the rectifier output voltage, in one case by means of tap-changing on the high-voltage transformer windings, and in the other by means of grid control of the ignition. Two sets of anodes are employed, supplied from separate transformer windings to provide voltage for series or parallel operation, depending on the position of the controller.

The series-commutator-motor locomotive carries eight motors designed for operation at 50 cycles. These motors have 14 poles and are mounted two per axle and controlled in the same manner as on the $16^2/_3$-cycle locomotives which are standard in Germany. Such motors are relatively heavy compared with motors for operation at lower frequencies, but this is offset by the saving in weight of transformers.

No data are available as to the relative operating advantages of these four types of motors, or indeed as to the 50-cycle distribution in this experimental project. It is to be hoped that information will be available in the not distant future.

A locomotive of high horsepower rating has been developed for operation especially on the St. Gotthard line of the Swiss Federal Railways, where grades of 2.7 per cent are involved. This consists of two cab units operating as a single locomotive. The wheel arrangement includes four driving axles in each half, or eight in all. The continuous rating of the 16 traction motors is 10,600 horsepower, the rating for one hour 12,000 horsepower, and 15,000 horsepower for 10 minutes. The weight of the two units complete is 513,000 pounds.

This unit has a double-reduction drive similar to that referred to hereinbefore, and the voltage control is on the high-voltage side of the transformer, consisting of plate-type contact taps arranged in a circle over which passes a motor-operated control arm, the entire mechanism being immersed in oil; 29 operating steps are provided. This locomotive is equipped for regenerative braking as well as carrying two compressors for supplying the braking system. Electric heat is provided for operation at 800 or 1,000 volts on circuits passing back through the train.

Recent locomotives having a wheel arrangement with six pairs of twin motors and a rated continuous horsepower of about 3,600 with short-time capacity of 7,600 horsepower, are in successful operation on the New Haven road. These locomotives are equipped to operate from either 11,000-volt single-phase trolley or 600-volt d-c third rail.

A type of locomotive that is operating satisfactorily on the Pennsylvania Railroad in passenger service at speeds up to 80 miles per hour and in freight service at speeds up to 50 miles per hour—either single or in multiple unit—has a similar wheel arrangement. The continuous horsepower rating of these units is about 4,600 and the short-time rating 8,500, nearly 90 per cent higher.

As has been indicated, the trend in electric-locomotive design is toward greater concentration of horsepower per locomotive unit, and by the multiple-unit operation to concentrate the horsepower available per train. There is a tendency to assign individual locomotives for either passenger or freight operation with obvious advantages, since the peak requirements in these two classes of service do not ordinarily occur at the same time.

Conclusion

Three general types of locomotives have been developed for railroad operation. Each type without question represents a good transportation tool and each has definite advantages. The developments applied in each type undoubtedly have been stimulated by improvements in other types, and each has thus been instrumental in helping the railroads meet the increasingly exacting demands made upon them for improvements in economy, efficiency, and service. It may be expected that advances will continue and that with further development in other railroad facilities the railroads will continue to serve as the country's most important transportation agency.

Getting Around in the City of the Future

ONE of the most important, and at the same time most controversial and least understood, problems of the modern city is that of improving its transportation or circulatory system. American cities have grown in area and in population at a rate that has far outstripped the facilities for handling the increased volume of local travel. In addition, development of the automobile has vastly increased the travel habits of everyone. But by jamming millions of automobiles into our existing street systems, we have made it increasingly inconvenient, costly, and dangerous to move about in urban areas.

Motivated by the general clamor and pressure to do something about urban street congestion, there is much hit-and-miss construction, dictated in too many instances by political pressure from groups who expect to benefit at the community's expense. There is also a strong tendency to assume that ultimately we shall all move about in private automobiles. Artists paint us beautiful pictures of the cities of the future, with their towering pinnacles and their skyways along which flow myriads of individual automobiles. Carried along by this attractive product of our imagination, we undertake huge outlays for street improvements which may or may not be wisely planned and which have a baffling way of becoming loaded beyond capacity almost as quickly as they are completed. In the meantime there is a tendency to ignore the vital public carriers and to overlook many opportunities for improving their facilities and service in carrying out community traffic-improvement plans.

CAPACITY OF CITY STREETS

If parking is prohibited, a typical city street with 60 feet of pavement width suitable for the movement of three lanes of traffic in each direction will have a capacity as indicated in table I. With automobiles alone moving on this street some 2,115 vehicles per hour represents its maximum capacity. This is based upon actual traffic checks made by competent engineers in surveys conducted under varying conditions. When public transit vehicles as well as automobiles move through the same street, the maximum number of vehicles per hour that can move satisfactorily drops to about 1,215. But the economic and social life of cities is not dependent upon the movement of vehicles; it is with the people in these vehicles that we are primarily concerned.

When we look at the capacity of our typical street in terms of the number of people served by the three alternative ways of using it, we get an entirely different picture of the situation. When used jointly by automobiles and street cars, this 60-foot street provides an artery for the movement of more than four times as many people as does the same street when used exclusively by private automobiles. This means that if we remove the street cars on such a street and devote its space entirely to use by automobiles, we shall require in addition to the old street, more than three new streets of the same width to have the same traffic capacity that we had before making the change—provided that we recognize, as we should recognize, that the proper measure of traffic capacity is in fact the number of people moved.

EFFECT OF WEAVING ON STREET CAPACITY

Carefully conducted studies have shown that the weaving of traffic from lane to lane on streets reduces efficiency markedly on wide arteries. Assuming the capacity of a single lane to be 100 per cent, if a second lane is added and traffic is not channelized by rigid enforcement, the additional space adds only 78 per cent to the capacity of the first lane. A third lane adds only 56 per cent, and a fourth only 26 per cent as much traffic capacity as that of the first lane. Thus, where weaving from lane to lane is not restricted four lanes will have a capacity of only 260 per cent; in other words, the effect of weaving is to reduce the capacity of 4 lanes in one direction to that of 2.6 lanes without weaving.

Table I. Vehicle and Passenger Capacity of a City Street

60-Foot Pavement—Three Lanes Each Direction—No Parking

	Vehicle Capacity		Passenger Capacity		
Types of Vehicles	Automobiles	Busses or Street Cars	Automobiles	Busses or Street Cars	Total
Automobiles only	2,115		3,700		3,700..All seated
Automobiles and busses	1,215	180	2,130	7,200	9,330..All seated
			2,130	9,000	11,130..Seated and standing
Automobiles and street cars	1,215	150	2,130	9,000	11,130..All seated
			2,130	13,500	15,630..Seated and standing

It is obvious then, that under congested conditions the way to get the maximum traffic capacity from a given artery is to confine the traffic to lanes or channels so as to avoid the losses engendered by weaving. The street car has been much maligned in modern traffic because it is rigidly confined to its lane by the rails upon which it operates. Assuming that we have available a rail car capable of holding its place in the traffic stream—which has been amply demonstrated with modern cars—the assumption that removal of rails in city streets in favor of free wheeled vehicles would increase the capacity of congested streets, is quite unjustified.

EFFECT OF SEPARATING GRADES AND INCREASED SPEED

To move more automobiles in congested areas it has been suggested that we need merely to build double-deck highways, to eliminate grade-crossing interference. Thus,

Excerpts from an address of the same title delivered at a meeting of the Engineers' Club of Baltimore, November 29, 1939, by Charles Gordon, managing director of the American Transit Association.

it has been assumed, we can provide our imaginary cities of the future with ample highway capacity so that workers and shoppers may drive themselves comfortably in swiftly moving streams of individual vehicles over skyways at various levels to and from their destinations in the lofty peaks that will pierce the sky in what are now congested business areas.

The available facts indicate some of the practical considerations with which we shall be confronted if we undertake to make these dream pictures come true. An ordinary city street four lanes wide, or with two lanes of automobile traffic moving in each direction subject to normal grade-crossing interference, has a conservative maximum capacity in each direction of 900 vehicles per lane per hour. When we build an elevated highway or a tunnel, we merely eliminate grade-crossing interference. Such crossing-free arteries have already been constructed to the point where we can accurately measure the increased capacity obtained. The Holland Tunnel under the Hudson River at New York, N. Y., serves as an excellent example. There careful traffic measurements have been made over a protracted period of time so that it has been well established that the maximum capacity of such an artery is approximately 1,500 vehicles per lane per hour, or 600 more than that of the conventional surface street.

Traffic will move at better speed on the grade-separated highway, and in that respect transportation is more satisfactory. But the capacity in number of vehicles per hour that can move past a given point, does not go up in proportion with the speed. Available data indicates a certain critical speed of about 30 miles per hour, at which the maximum number of vehicles move through a given artery in a given time.

CAPACITY OF LANES WITH VARIOUS VEHICLES

Returning now to consideration of capacity in terms of passengers rather than vehicles, table II gives a comparison of the relative capacities of various methods of moving people in congested areas. These figures give some interesting comparisons. Note particularly that the passenger capacity of a lane of busses on a surface street is about $3^1/_2$ times that of a lane of automobiles on an elevated highway. The capacity of a lane of street cars on a surface street is about 5 times that of a lane of automobiles on a skyway. If we also put the street cars in or on a grade separated structure to provide a direct comparison, their capacity becomes $7^1/_2$ times that of a corresponding lane of automobiles.

Table II. Capacity of a Single Lane of Various Types of Conveyances in Passengers Per Hour

Automobiles on surface streets	1,575
Automobiles on elevated highways	2,650
Busses on surface streets	9,000
Street cars on surface streets	13,500
Street cars in subway	20,000
Local subway trains	40,000
Express subway trains	60,000

We can now make a direct comparison of two alternative methods of building our cities of the future. Shall we provide subway trains for transporting our passengers or elevated highways for transporting them in private automobiles? Admittedly subways are expensive and beyond the resources of most cities until population and traffic densities can justify their cost. A four-track subway structure comprising two local and two express tracks costs from 6 to 18 million dollars a mile; but a subway of this type has a capacity of 100,000 passengers per hour in one direction on two of its tracks. It would require 21 four-lane elevated highways filled to maximum capacity with private automobiles to move 100,000 people per hour.

There is still another factor to be considered. Assume that we can build highways in our cities so that all workers and shoppers can transport themselves in their own automobiles, and that they can afford to do so. Before these people can function at the point to which they have been transported there must be space for the vehicles they leave. Authoritative statistics are available from which the requirements to be met can be readily determined. In central business buildings of modern type the floor area required per worker averages about 150 square feet. Corresponding studies of the space needed for the storage of automobiles in the most modern types of ramp or elevator garages indicate an average floor-area requirement of 240 square feet per automobile. Crediting each vehicle with the average loading in city traffic of 1.75 people per car gives a storage space requirement of 140 square feet of floor area per person. Thus the storage requirements for automobiles in the most modern types of garages average very closely per person transported the same as that occupied by workers in modern central-area business buildings. This comparison makes no allowance for the storage of cars by those who come into these districts to do business as shoppers and otherwise. Here then is the problem with which we are confronted if we are to approach the matter of improving the travel facilities in our cities on the assumption that everyone is ultimately to ride in individual automobiles.

With these facts in mind the transit industry today is fully conscious of its responsibility. The industry recognizes that it can win greater public use of its service and public co-operation in the appropriate allocation of street space to public and private vehicles only as it can demonstrate that it is alert and progressive. To that end remarkably rapid progress has been made during the past five years in the development of improved vehicles for urban transportation. The bus was originally a makeshift adaptation of a truck chassis. Today it stands as a full grown transportation vehicle in its own right. Crossbred between the bus and the electric car is the trackless trolley which has proved itself a very valuable and useful vehicle for urban transportation. When the size of vehicle required reaches 40-passenger capacity, and the service conditions require frequent stops, the trackless trolley adequately meets the problem of providing sufficient power by resort to the overhead trolley, while at the same time retaining to a considerable extent the maneuverability of the bus. Finally the street car itself has undergone a complete metamorphosis. Starting in the fall of 1929 and continuing to the present date, a research program supported by some 50 operating and manufacturing

companies in the transit industry resulted in the development of the so-called Electric Railway Presidents' Conference Committee car commonly referred to as the PCC car. Here again the public vehicle has thrown precedent to the winds and has pioneered a number of radical developments.

Thus through many developments the transit industry is trying to meet the demand for improved urban transportation. But this objective can be fully achieved only if the importance of public transit service in modern cities is recognized by leaders of public thought.

The part that any one mode or vehicle of urban transportation is to play in the future must be judged on the basis of its economic and social value to the community. The subject should be approached first of all as a civic matter. When plans for the improvement of a city's circulatory system are under consideration, the interests of any section, group, or business must be subordinated to the needs of the community as a whole.

The demonstrable economic advantage of collective transportation justifies the suggestion that through encouraging the development and greater utilization of such facilities a community may contribute most economically toward the improvement of modern traffic conditions. A much higher standard of convenience and comfort is needed if we are to achieve greater utilization of public facilities. That requires in turn the fullest co-operation between a community and its transit company.

Engineers in particular have a great opportunity and a great responsibility in the field of urban transportation. Not alone as engineers, but as citizens of their community they are in position to aid in the adoption of sound civic policies through their ability to understand the intricate problems involved. The future development of our cities will be influenced by psychological and political reactions as well as by economic and engineering considerations. Urban transportation problems will be worked out not alone in the drafting room and the laboratory, but in the arena of daily life where the public is the judge and where economic and engineering data may be outweighed by visionary schemes which appeal to the popular imagination.

Supersonic Light Control and Its Application to Television

THE principal element of the Scophony Laboratories (London, England) system of television is described in a recent paper.* The Scophony system, using entirely optical methods, has set the pace for large-screen television in England. The method employed can produce high-quality pictures up to 15 feet wide as well as 18- and 24-inch domestic pictures.

The author describes briefly the methods of television from the early days of the Nipkow disk to the present cathode-ray methods and then points out that the Scophony system of supersonic light control gives for the first time a practical means of storing picture signals at the reception end and brings to the receiver the advantages of electrical storage that the Iconoscope brought to the transmitter.

The basis of the Scophony method is the diffraction of light by supersonic waves in a liquid—a phenomenon demonstrated by Debye and Sears and shown by Jeffere as a possible basis for a light control of negligible inertia and power consumption and reasonable light efficiency. This type of light control makes it possible to modulate a beam of light from an independent light source and to project it directly onto a screen to form a large picture.

The construction and elements of the method of operation are best described in the words of the author. "The supersonic light control consists of a glass-sided cell filled with a transparent liquid, with a piezoelectric crystal having a natural frequency between 5 and 30 microseconds immersed in the liquid or inserted in one wall of the cell. The crystal is provided with electrodes on opposite faces, and these electrodes are fed by a high-frequency carrier, the frequency of which is approximately that of the crystal, and the amplitude of which may be modulated by the video signal received from the transmitter."

This arrangement causes the mechanical vibration of the crystal which is transferred to the liquid, thus forming a train of supersonic waves in the liquid through which light is passed. Since the supersonic wave length is small, diffraction spectra are produced proportional to the high-frequency carrier applied to the crystal. By stopping out the normal beam and using the light from the side images, an intensity proportional to the received video impulse appears on the screen.

The combination of this supersonic light control with cylindrical lenses as a means of increasing the amount of light that can be dealt with is the feature of the Scophony system that permits the production of large images. The practical form taken by the apparatus is described in an article titled "The Design and Development of Television Receivers Using the Scophony Optical Scanning System," by J. Sieger, pages 487–92 of the August 1939 *Proceedings* of the IRE. In the same issue, pages 492–6 appears an article "Synchronization of Scophony Television Receivers," by G. Wikkenhauser, giving data on the scanners of the Scophony system followed by H. W. Lee's article "Some Factors Involved in the Optical Design of a Modern Television Receiver Using Moving Scanners," pages 496–500. This last article discusses the optical efficiency and accuracy tolerances of the Scophony scanners.

*Abstracted from a paper "The Supersonic Light Control and Its Application to Television With Special Reference to the Scophony Television Receiver," by D. M. Robinson, published in the *Proceedings* of the Institute of Radio Engineers, volume 27, 1939, pages 483–6; abstract prepared under auspices of a special subcommittee of the AIEE committee on research (D. C. Jackson, Jr., chairman) by Ferdinand Hamburger, Jr. (A'26, M'32) instructor in electrical engineering, The Johns Hopkins University, Baltimore, Md.

Present Trends in Engineering Education

Increasing emphasis on research for undergraduates, widening recognition of the need for better pedagogical methods, and growing attention to the social relations of engineering are among desirable tendencies noted in a recent survey of engineering education

IS engineering education improving in its adaptation to its purposes, and are the observed defects being remedied? These two questions may be partially answered by tracing the trends in ideals and practices among the engineering schools. I will anticipate the ensuing statement of important trends by saying that the answer to each of these questions is a qualified affirmative. The situation is not wholly satisfactory respecting either feature, but the trends generally are good.

Two trends of great importance are the widely spreading recognition of the need for improved pedagogical methods with more responsibility placed on the individual students for self-education, associated with more sympathetic and wisely directed supervision, encouragement, and counsel from the staff, and the fuller acceptance, as a tenet, of the significance of research for the education of engineering students in the upper undergraduate years.

There goes along with these a generally increasing recognition among competent engineers that an engineering faculty of high intellectual and professional qualities usually attracts students of high order, whether the institution is of moderate financial circumstances and moderate facilities, or of great wealth and correspondingly great facilities. It is coming to be clearly seen by engineers that, to quote the Carnegie Foundation bulletin "The Student and His Knowledge," published in 1939,

"The best part of education for youth is to come in contact with stirring personalities that have had great adventures with ideas. If a young mind can recognize what these ideas mean and whither they tend, it is undeniably the greatest possible stimulus for him to catch these meanings from a living person."

But it is well here to emphasize that for engineering students the phrase "contact with" must be understood as meaning "association with and working with, or under the intimate counsel of." Unhappily, this relation between the quality of students and the quality of the teaching staff is not always suitably recognized by administrative officers when making appointments or promotions.

The criteria applied to selecting and promoting staff appointees are in a badly mixed trend. In a few institutions notable effort is exercised to achieve a staff with the personal qualities recognized as important. In other institutions, there seem to be no such guiding principles, but other and less desirable criteria seem to be controlling. Data are not sufficient to prove that the trend has been one way or the other compared with the increasing aggregate number of staff members, but they do plainly show that the trend toward outstanding influence of some engineering schools (compared with others) has been coincident with increasing repute of their teachers in engineering thought, in contributions to engineering knowledge, and in encouraging their own close intellectual relations with ambitious and competent students.

With respect to students, it has come to be recognized in some degree that "the intelligent interest which the individual brings to bear upon a given subject" outweighs in importance for students of engineering the amount of time spent in formalized class exercises. The combination of this attitude and the practice of selecting more judiciously students to be accepted by the engineering schools seems to be raising the level of student achievement wherever the two ideas are joined in use.

The effect on student achievement that may be secured by student selection, carefully made and carefully maintained, is favorably commented on in "The Student and His Knowledge," which ascribes it to the fact that such selected minds "naturally tend to learn more than the curriculum requires; they are inclined to organize and to retain better than others what they learn." However, the existence of such trend-relations may be denied by many sincere administrative officers and staff members in engineering schools, and a fuller examination of such experience as now exists in the schools is necessary to give final proof to the point.

It is obvious that some engineering schools are directing increased care to the processes of selecting students (and particularly to selecting freshmen); and along with this, there is a growing attention to improving the study practices of the students, associated with encouragement to intellectual self-reliance. Financial aid for students is now being dispensed more steadfastly and judiciously with student selection in mind, whether the funds are provided through scholarships, student loans, or such other means as the plans of Stevens Institute and Yale University. Foremost quality of student achievement has gained the lead compared with quantity of mediocre achievement, and those who are often called the "superior" students receive more attention. It still apparently is difficult for faculties to take students at their individual levels and encourage them to progress at individual speeds, but some special devices, such as honor seminars in junior and senior years, show that the difficulty has begun to dissolve.

A slowly widening interest among the engineering schools in examinations of truly comprehensive character, and reduced emphasis on term examinations in individual subjects, is a trend which is now observable. Comprehensive examinations placed as qualifying examinations before promotion from the sophomore to the junior year have been discussed.

Digest of section VIII, "Present Trends in Engineering Education", of *Present Status and Trends of Engineering Education in the United States*, a report prepared by Doctor Dugald C. Jackson (A'87, F'12) for the committee on engineering schools of the Engineers' Council for Professional Development and recently published by the committee. The chart and table accompanying this article are adapted from material in section VI of the report.

Conventional and highly predigested textbooks continue in use in even the most dynamic branches of engineering, but stimulating treatises are not lacking for use. The latter are receiving increasing favor in institutions where teaching loads are not overheavy.

These things seem to go in association with the distinction of a faculty for its own achievements in science, engineering practice, and pedagogy; and reputation in those respects is tending to draw selected students to certain institutions for advanced study.

The increasing interest in student meetings of the national engineering societies (by districts or at general meetings) is a trend of notable importance which now has strong momentum. It proves a valuable aid to developing in the students a feeling of responsibility for their own self-education and (once established in this manner) this sense not only holds within college but also, happily, is maintained after graduation. Prizes offered for papers presented at such student meetings and other meetings of the societies are an effective part of the same active interest in the education of engineers that is now exhibited by the engineering societies. These meetings should afford an opportunity to emphasize the topics of engineering economy and of management, regarding which committees of the Society for Promotion of Engineering Education are doing such fine work.

One of the most encouraging features of the trends relating to student selection and improvement of study processes is arising in a few strongly entrenched engineering schools within which department border lines have been weakened. That is the tendency to carry on experiments in education and research in which more than one department takes an active interest. A somewhat analogous feature lies in the offering of experimental curricula that relate to developing aspects of engineering which have not yet been sufficiently mature to prove their ultimate stability.

SOCIAL RELATIONS AND RESPONSIBILITIES

A very impressive trend lies in the rather recently emphasized attention to the social relations of engineering and the social responsibilities of engineers. This trend is a very wide and fruitful affair which touches engineering education on all sides, from such monumental questions as the effect of engineering practice and invention upon private and public expenditures, to such administrative problems within the engineering schools as the proportion of admitted students who withdraw before graduation. One of the significant manifestations of this trend is to be observed in the interested co-operation now established between the national engineering societies, the Society for the Promotion of Engineering Education, and the numerous centers of engineering education. The Engineers' Council for Professional Development, with its four committees related to the education and professional recognition of engineers, is an outcome of this sympathetic co-operation between the societies and the instrumentalities of engineering education. The same influence of an expanding sense of social responsibility has favorably affected the co-operation between industry and the engineering schools, and between individual practicing engineers and the schools. In this, the engineering schools ought to develop a more thoughtful part, emphasizing pedagogical ideas.

This same broad question of social responsibilities involves the present high rate of broken student careers and also involves, in an administrative way, the organization of engineering schools. The woefully large proportion who enter the engineering schools as students but who withdraw for one reason or another before reaching the goal of graduation has been commented on again and again in conferences and reports, including the report of the SPEE board of investigation and co-ordination of 1923–29. A portion of the effort of such students is profitable to them but with many it is a plain waste of time and money. The ECPD committee on student selection and guidance hopes to discover measures for selecting the students who enter the engineering schools and also for providing some guidance for them so that the great waste may be lessened.

Into the broad field of social responsibilities for the institutions also comes the growth in popularity and in numbers of junior colleges. Their trend is forward and upward and many of them now include instruction in engineering subjects. The relation of such instruction to preparation for entering the engineering schools with scholastic credit is still in the stage of discussion.

TRENDS IN CURRICULA

Study of curricula reveals in some cases distinct trends and in others erratic variations. A dynamic three-quarters of a century, with vigorous growth of curricula amid clamoring expressions of needs, affords neither length of time nor calmness of spirit adequate to the clear outlining of principles and objectives for the educational processes in a great field of human endeavor where the field is open for free development. The results in engineering have been astonishingly good for the circumstances, as has been shown by the SPEE report of 1923–29. There has been in engineering education a long swing of changing proportions of subjects, changes of pedagogical methods, and formulation of specific curricula. The total trend has been and is one of steadily expanding accomplishment. Devoted and learned men have dedicated their lives to the achievement, often under discouraging circumstances. They have stirred large numbers to discipleship. Under the circumstances, the steadiness of the principal trends regarding curricula is notable; and this steadiness persists in the face of constantly applied examination of the educational situation.

The data show that the civil engineering curricula came to their highest concentration of technical subjects about 1915, and that the tendency since then has been a slight retreat. The same may be said of the curricula in electrical engineering. The mechanical-engineering curricula, however, came to their highest concentration of technical subjects somewhat later—about 1923. They have not shown the tendency to a retreat from this situation which is shown by the others, and at the present time exhibit a slightly stronger emphasis on technical subjects than the

data show for civil and electrical engineering. The trends in electrical-engineering curricula are shown in the accompanying chart. The great significance of these data, however, seems to be in the trends regarding time-allotments for arts of expression (spoken, written, and graphic), humanistic and social subjects, and free electives. The data show that English has substantially held its own (in hours assigned) over several decades, graphics have fallen off, and foreign languages have substantially disappeared, leaving a balance of freed hours. Economics and sociological subjects and free electives have taken up the freed hours. Shopwork may, here and there, have given up a few hours to the same cause.

This adjustment is worthy of the closest examination for the purpose of securing more hours for political economy and restoring some to foreign modern languages. An encouraging tendency of thought is observable in this field, but it is slight as yet and does not reach the heart of the situation.

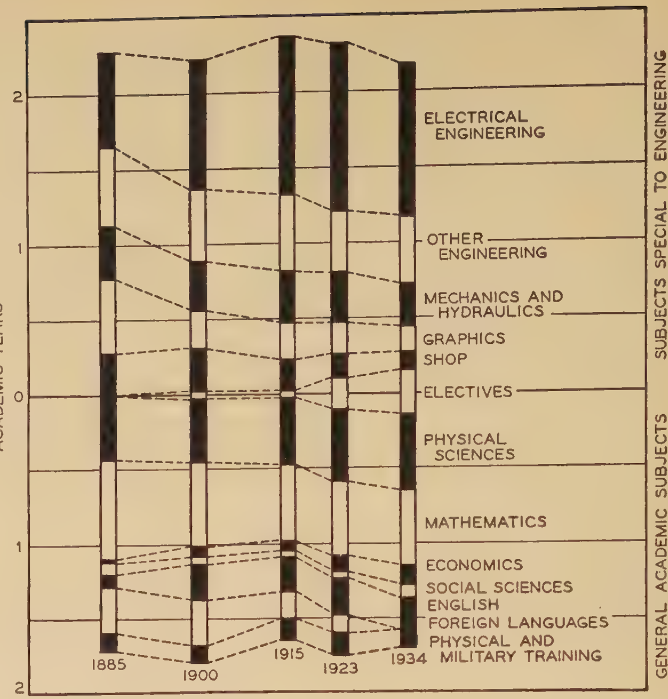
The change in attitude within the engineering schools toward instruction in English has been almost revolutionary. From a subject accepted as an item of the curriculum with only a degree of toleration, it has come to be esteemed alike by faculties and students (as well as by engineers in general) as an important feature in competent engineering curricula, but there is great need for resourceful originality applied to processes of teaching the subject. The work of the SPEE committee on English may do a great deal toward capitalizing on that situation. The conferences of that society on English instruction are having a good influence. At the same time, the foreign modern languages have lost support in the engineering schools, but an indication is appearing of some reversal of sentiment regarding them.

The trend in mathematics and the natural sciences has been strongly toward better grasp of the subjects by students. A part of this accomplishment arises from better-adapted teaching methods and another part from a better attitude toward research for students in the higher engineering classes.

Attitudes expressed within engineering circles toward the importance of economics and sociology (which here will be called jointly "political economy") as subjects for close and accurate study by engineering students have changed tremendously in the emphasis put on the words "importance," "close," and "accurate." But faculties have been slow in conceiving measures for accomplishing the purpose. It probably is a fact that engineering faculties now generally agree on a need to dovetail engineering into political economy in the curricula so that the two may directly and soundly influence each other, as has been done so well with engineering and the physical sciences, but the means for accomplishing this aim have not been set up. Many attacks on special aspects of the broad relations of the two are carried on with interest and apparent success, but no vigorous attack on the fundamental core of the joint problem has been provided as yet; and nowhere have funds been made available to support adequately such an attack.

The present tendency is for each institution to provide a considerable number of curricula, each possessing a large proportion of material that is substantially common to all, although the teaching methods and illustrations may be different, with each curriculum emphasizing the particular applications toward which it is directed. Thereby is obtained a freedom of choice among special fields needed to satisfy the legitimately diverse tastes of students, and also some freedom of choice among subjects by the provision of electives, while an integrally conceived but flexible plan is available for each student to follow. Some notably able engineering teachers preach an adverse doctrine, but the gradual increase in the number of soundly established and respected curricula shows the force of the trend. It is, however, becoming generally accepted that such curricula should be sufficiently similar during the first two years that students may readily transfer from one to another at the end of any term during that period.

A paramount problem, which needs to be settled before the dispute over length of curricula and the desirable extent and character of their diversity, lies in the definitions of the "fundamentals" of science and of political economy. Along with this goes the question of how much of each aspect of fundamental science and of fundamental economics and of fundamental sociology is needed in the composition of the common core in engineering curricula. Until these points can be decided, the trend of thought regarding variety and length of curricula will continue to be erratic because controlled by incomplete experimental empiricism. In our present situation, difficulties caused by problems of congestion in curricula sometimes have more directive force than good pedagogical philosophy; and convenience of administration some-



Evolutionary trends in electrical-engineering curricula

Continuation of trend chart in the Report on Investigation of Engineering Education, 1923-29, Society for the Promotion of Engineering Education. Data for 1934 are from the questionnaires of the committee on engineering schools, Engineers' Council for Professional Development

times has more influence than the production of continuity of thought and endeavor for the students.

The evolutionary trends of every important branch of engineering practice result in constant demand for changes in engineering education, and the now notable tendency to establish experimental curricula or introduce newly defined experimental subjects of instruction seems to be legitimate and likely to continue but needs careful restraint in performance. The ECPD committee on engineering schools faced this situation with courageous wisdom tempered by cautious liberality.

EVENING CURRICULA AND CO-OPERATIVE COURSES

Out of changes in engineering affairs, and particularly changes of industry, have come the impulses that have produced evening curricula leading to engineering degrees and also those that have produced co-operative courses. Although undergraduate curricula are now under consideration it is to be remembered that these several threads of development also are appropriate for planned graduate work. It is becoming accepted that engineering schools located in centers of diversified industry have an obligation to the citizens of the community and to the industries to make engineering education possible to all who demonstrate competency, desire, and fitting personal qualities. Out of this situation has arisen the strong trend toward evening curricula in industrial cities.

The earlier evening schools were relatively meager and of thin quality, but the content of evening engineering curricula has come to equal in extent and grade the content of the day curricula in certain institutions. The arrangements for suitable engineering teachers in evening work are improving and the relations with industries whose employees pursue these evening curricula are also improving. The trend is toward full equality between day and evening curricula in those institutions that grant like degrees for both.

The trend in firmly established co-operative courses is toward periods of interchange between college and works longer than those Dean Schneider originally set up at the University of Cincinnati, with an approach to periods which are coterminous with regular college terms, as adopted at the Massachusetts Institute of Technology when the electrical-engineering co-operative course was established there. A tendency to reduce the extent of competent academic work which had appeared in some of such curricula apparently has been turned by the effect of consultations with the ECPD committee on engineering schools. The responsibility of industry for a mutual interest in the co-operative engineering courses is being more fully invoked, which adds generally to the welfare of engineering education. The depression has caused modifications of details in many instances, but the principle has survived its destroying influence unexpectedly well, and industry continues to turn favorably toward co-operation in various aspects of engineering education.

LACK OF CLEAR DEFINITIONS FOR GUIDES

The dynamic changes which have been affecting all important engineering branches have tended to blunt the keenness of definitions of the purposes of engineering education, as far as such existed. That is, the definitions of engineering education that are to be inferred from printed and spoken statements seem to grow less exact. Here is an important task that is open for the ECPD committee on engineering schools—that is, the formulation of a broad but convincing definition of the purposes of engineering education.

A notably fruitful trend is the increasing recognition that research is an important part of undergraduate engineering education, and that students in the upper classes should be made aware of its value and participate in it. However, it is not necessary to support elaborate graduate work or great research projects for the purpose of securing a substantial influence of research on undergraduates. That is being accomplished by the effect of suitable men on the staff in some institutions in which little or no formal graduate work is provided; but the spread of this tendency among such institutions is yet rather narrow and there are no clear-cut definitions of the possibilities by which administrative officers may be guided.

It is clear that there is an increasing recognition by the public in general that a superior order of intellectual qualities is required for gaining important achievements in engineering, and that superior moral qualities are required in support of the achievements when they are gained; also, that theory must be tempered with practicality in engineering; that character stands before knowledge among engineers; and that study of technical subjects teaches character in its features of intellectual honesty and steadfastness of purpose. It is equally clear that this growing public recognition increases the responsibility of the engineering schools and their faculties to produce education of high professional caliber in association with technical competency, but in this, again, clear-cut definitions are lacking.

ENGINEERING-SCHOOL FACILITIES

The lagging tendency in the development of interested participation by the teachers in professional engineering and professional educational matters (which may be an indication of their professional standing) may be illustrated by the extent of participation in professional society affairs. the accompanying table, based on figures from the ECPD report, shows the relationship between society membership and recognition in leading biographical directories.

Teachers for engineering schools are drawn from the institution in which they are chosen to teach, from some other institution, from engineering practice, or through some combination of these. There seems to be no appreciable change in the practices except that the greater engineering schools located here and there through the country are now more frequently than in the past securing for an important post some young man who has been proved worthy of his spurs in industry. The ECPD committee on engineering schools commented that "the securing of the right kind of teachers is a major problem in engineering education." It is only the exceptional institution to which there is no applicability for the comment,

Distinction of Full Professors in Five Major Engineering Fields, as Measured by Listings in Biographical Directories and Membership in Professional Societies*

Field of Engineering	Number of Professors	Percentage of Professors: American Men of Science, Starred†	American Men of Science, Listed (Inc. Starred)	Who's Who in America	Member of Engineering Society (Own or Other Field)	Member of Society for Promotion of Engineering Education
Chemical	99	6	79	28	59	46
Civil	347		62	28	76	68
Electrical	209	4	78	35	92	75
Mechanical	370		62	25	71	65
Mining and Metallurgical	111	2	86	43	72	37

* Engineering societies included are American Institute of Chemical Engineers, American Society of Civil Engineers, American Institute of Electrical Engineers, American Society of Mechanical Engineers, American Institute of Mining and Metallurgical Engineers. Figures are based on 1938 membership lists, except for ASME, for which 1937 membership list was used. Biographical directories used: American Men of Science, 1938 edition; Who's Who in America, 1938–39 edition.

† Indicates the 1,000 whose work is regarded as most important.

made by Dean A. A. Potter in his 'Report on the Engineering Schools of Land-Grant Colleges," that teaching staffs on the whole gave little observance to developing the most desirable processes for instruction of competent students. In some institutions the tendency for improvement is strong, but in many institutions it lags. Excessive teaching loads, insufficient salaries, isolated locations, lack of encouragement from executive officers who themselves are inadequately informed regarding the needs of engineering education, all may have a part in responsibility for this lag.

A wider adoption of reasonable retirement and pension policies is a desirable present trend in the treatment of engineering teachers. Salaries, extent of conventional teaching loads, and facilities provided for the teaching stand about stationary, except in some notable institutions. The selection of new staff members still seems to rest unduly heavily on academic degrees, although some engineering schools offset this by a large recognition of vivid experience in engineering practice, thus partially avoiding a policy of putting the degree first and the man second. It is moderately well recognized that an investigatory spirit and achievement are more important for an engineering teacher than higher degrees. But men of investigatory spirit and achievement have so many opportunities that the low level of salaries and unencouraging conditions of a considerable proportion of American engineering schools fail to attract such men.

Whatever trends the depression may have introduced in the procedure of selecting staff members, probably its greatest effect has been to decrease the flow into industry from among the younger staff members; thus reducing turnover among members of the staff and reducing the normal opportunities for retaining in the engineering schools only those whose spirit serves best for the place. It is not likely that any one can predict whether or not this will have an unfortunate future effect.

Competent engineering education demands an intimate interrelation of teaching, research, and engineering practice. The trend has been toward bringing research from a backward position to its proper place of equality among the trio; and this trend is now operating among those engineering schools which were slow in catching the impulse. Quite a few engineering schools which secured the research spirit fairly early and have cultivated it strongly tend to emphasize research as the major enterprise. This may be at the sacrifice of attention to both teaching and practice. The condition can be avoided by a staff possessing the fully developed professional engineering attitude that leads to intimacy with professional engineers through engineering societies and to intimacy with industry through conferences.

INSTITUTIONAL TRENDS

The old-time character of institutional jealousies has been for a considerable period in course of softening and this has resulted in a trend of potentially great importance, namely, co-operation between institutions, individually and by types. Unhappily, a trend now exists which disturbs the balance in the wider aspects of education within the field of engineering. This is the tendency of technical institutes to change into degree-granting engineering schools. The need in the engineering field is not for fewer students in the aggregate of those who are preparing for higher engineering work plus those who are preparing for the engineering trades, but for better-sifted engineering students in the engineering schools and an increased proportion of technical-institute students looking forward to the engineering trades. The tendency is in the opposite direction from the needs. Its strength is increased by the manner of administering engineer-licensing laws in several of the states, by which engineering-school graduates are credited with an equivalent of practice on account of their degrees while those without degrees do not secure such credits for their studies. This trend is causing more unbalance than ever of our already unbalanced educational provisions in the technical field. No means have been proposed for offsetting this unfortunate situation. A correct trend would be toward an increase in the number and excellence of technical institutes for training competent technicians in all industrial divisions of the country.

Illumination Notes

Floodlights for Night Baseball. The sixth major-league diamond to be floodlighted for night baseball will have its night premiere in June. The New York Giants have contracted for a floodlighting system for the Polo Grounds, which, it is said, will be the most powerful on any sports field thus far. Eight towers, 150 feet tall, carrying a total of 936 lights of 1,500 watts each, will be supplemented by additional lights on the grandstand roofs. The installation is further evidence that night baseball pays.

Contributed for the AIEE committee on production and application of light by L. A. Hawkins (A'03, M'13) executive engineer, research laboratory, General Electric Company, Schenectady, N. Y.

The Capillary Mercury Lamp as an Oscillograph Light Source

H. H. SKILLING
MEMBER AIEE

With the capillary mercury lamp as a light source, oscillograms may be recorded on bromide paper at speeds up to 50 feet per second

APPROXIMATELY twice as brilliant as a carbon arc, and some 12 times brighter than the filament of an incandescent projection lamp, the capillary mercury lamp is obviously a desirable light source for use with oscillographs. (See reference 1 for a short discussion of the optical systems of common types of oscillographs.) The capillary mercury lamp is a small quartz tube containing a small quantity of mercury, with an electrode at each end. When operating it passes current through mercury vapor at a pressure of 100 atmospheres or more. It was developed by Cornelis Bol, research associate at Stanford University, who did the initial work while with the Philips Lamp Works of Holland. Such lamps are now commercially available.

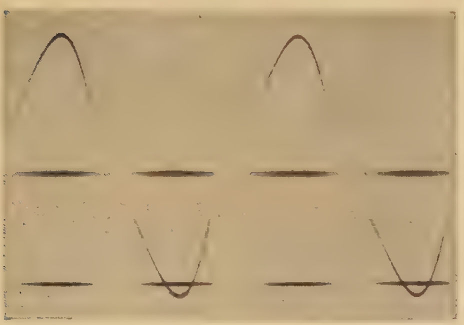


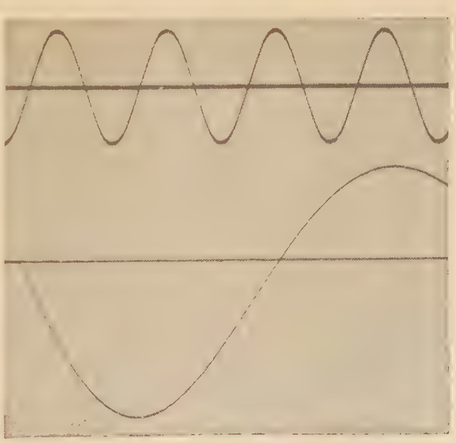
Figure 1. Oscillogram made with a capillary mercury lamp, operating on 60-cycle current, as light source. The wave is a record of lamp current

The advantages of the Bol lamp for the oscillograph are its ease of operation, and high intensity of light emission. Its brightness permits photographic speed greater than has previously been possible. For many purposes, however, a more important advantage is that it makes possible the use of relatively insensitive photographic media. Bromide paper, for instance, is much cheaper than film, as well as being easier to handle, and requires no photographic printing. Panchromatic emulsions are unnecessary with the Bol lamp, and its photographic speed is even greater than is indicated by its brightness, for the mercury light is of a highly actinic blue-white color. (See reference 2 for a spectrogram of light from a mercury lamp by Bol.)

The disadvantages of the mercury lamp are that it requires relatively high voltage (several hundred volts, depending on the design of the lamp); it is stroboscopic, going out between half cycles when operated on alternating current; and it requires a constant stream of cooling water.

Alternating current of the proper voltage can readily be obtained from a transformer connected to commercial power lines, but is unsatisfactory for oscillographic use because of the stroboscopic effect. Figure 1 is an example of an oscillogram for which the light source was a capillary mercury lamp operated on 60-cycle current. The wave shown is the actual lamp current, and as may be seen there is no trace while the current passes through zero.

To avoid the stroboscopic effect the lamp may be operated on direct current. This was done in obtaining figure 2, which is a record of an oscillatory transient current with a trace of a 60-cycle wave for calibrating the time scale. Figure 2 was made on photographic paper (News Bromide of the Eastman Kodak Company) at a paper speed of slightly less than four feet per second. Higher speeds are easily possible, and the first part of this same transient current appears in figure 3 as recorded at a speed of 16 feet per second. This was the mechanical limit of speed of the oscillograph, but the lamp is capable of recording on bromide paper up to speeds of 50 or more feet



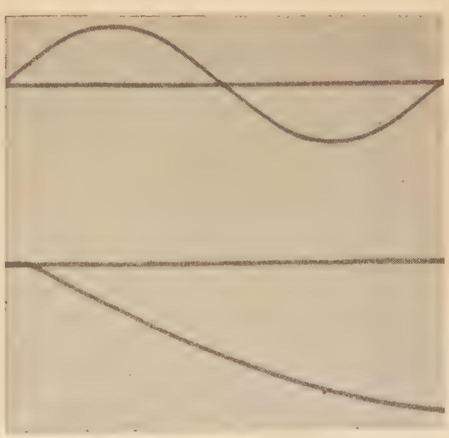


Figure 2 (left). Oscillogram made with a capillary mercury lamp, operating on direct current, as light source. One wave is a transient current, the other a 60-cycle timing wave

Figure 3 (right). Identical with figure 2, but at higher speed

H. H. SKILLING is associate professor of electrical engineering, Stanford University, Calif.

per second. With sensitive photographic film, speeds of several hundred feet per second could be used.

Photographically, the mercury lamp operating on direct current gives excellent results. But there are two electrical disadvantages to the use of direct current. The first is that a source of direct voltage of several hundred volts must be available. This requires either a special generator or a rectifier. It also increases the hazard; alternating current may be transformed to lamp voltage at the location of the lamp, while leads for high-voltage direct current must be carefully protected everywhere between the lamp and the d-c source. The second difficulty is in starting the lamp, for it will not always start on a voltage that is sufficient to maintain it in operation. With alternating voltage the crests of the waves provide a starting voltage that is greater by the square root of two than the effective operating voltage. When direct current is used it is satisfactory to apply operating voltage to the lamp and then to initiate the discharge with a spark from an induction coil that is connected (through a blocking capacitor) across the lamp. As an alternative means, a lamp that has been warmed up on alternating current will continue to operate if switched quickly to direct current of operating voltage.

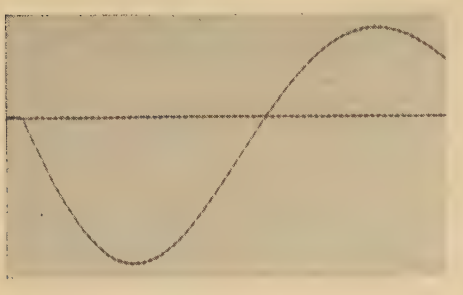


Figure 4. Oscillogram made with a capillary lamp, operating on 500-cycle current; similar to figure 2, except that no timing wave is required

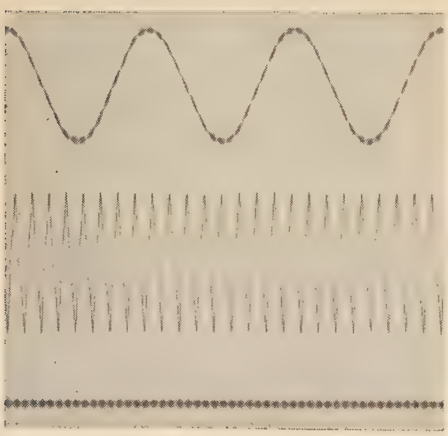
A minor disadvantage of d-c operation is that the series ballast in the lamp circuit must be resistance instead of reactance, which reduces efficiency.

To avoid the disadvantages of both 60-cycle and d-c operation the lamp may be operated on alternating current of relatively high frequency. Figure 4 is similar to figure 2 except that the lamp was supplied with 500-cycle alternating current. The stroboscopic effect is still evident, but it is not objectionable as in figure 1. Indeed it is decidedly helpful, for each dot of the recorded trace represents $^{1}/_{1,000}$ second, and no auxiliary wave for timing purposes is needed. Intervals of time are measured by counting the dots, which give time in thousandths of a second with no measurement of distance or computation of any kind. The paper speed for figure 4 was 3.8 feet per second.

The intensity of the trace is greater with a-c operation, power input to the lamp and other conditions being the same, for the light intensity at the crests of the current cycles is greater than the steady light produced by the same effective value of direct voltage.

Figure 5 shows the actual lamp current, a 60-cycle wave, and a straight-line trace. The lamp current was of 500-cycle frequency, and its use as a measure of time is seen by reference to the 60-cycle wave. The record of lamp current shows that the light dims after each half cycle of current, but it is clear on the original oscillogram that there is nevertheless a continuous trace, showing that the lamp retains some brilliance even while the current is zero. (The mercury lamp, indeed, is brighter when it is "out", between half-cycles, than is the carbon arc at its brightest.)

Figure 6 is similar to figure 5, but with the speed of the recording paper increased to 16 feet per second. At this speed it appears possible that essential parts of the oscillographic record might be lost by taking place between the dots of the record, but apart from the fact that there is a visible trace connecting the dots it must be remembered that the time of relative dimness is about 0.0002 second, and a mechanical oscillograph will hardly respond with accuracy to any fluctuation in so short a time. However, there is no assurance of a complete record if the lamp is supplied with 60-cycle current, for not only is the interval longer, but also there is less persistence of luminosity to provide a continuous trace. It would be particularly unfortunate if a 60-cycle supply to the lamp were so synchronized with a 60-cycle wave being recorded that all the wave crests failed to appear on the oscillogram.



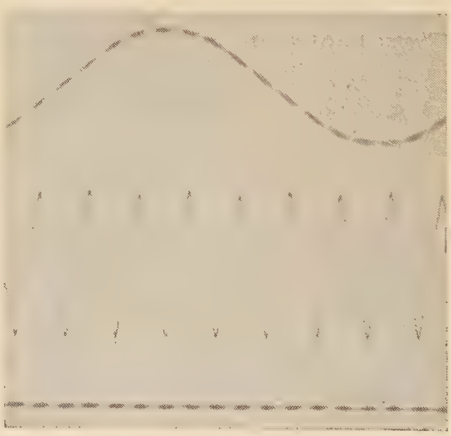


Figure 5 (left). Oscillogram made with a capillary mercury lamp, operating on 500-cycle current, as light source. The middle wave is a record of lamp current

Figure 6 (right). Identical with figure 5, but at higher speed

One of the minor advantages of 500-cycle operation of the lamp is the small transformer required, and the small inductance needed for ballast in the lamp circuit. The obvious disadvantage is that a source of 500-cycle power must be available.

The oscillograms shown were made with capillary mercury lamps of about 500-watt capacity. The lamps used have a luminous column of one-centimeter length.

They operate on voltages between about 350 and 500 volts; at lower voltages their operation is unstable and at higher voltages their life is short. Actual operation was at 360 to 380 volts, for this gave sufficient light and the life is several times greater than at 500 volts.

Similar lamps, but with a 2.5-centimeter length and an 840-volt 1,000-watt rating, are commercially available. These give equally good results.

References

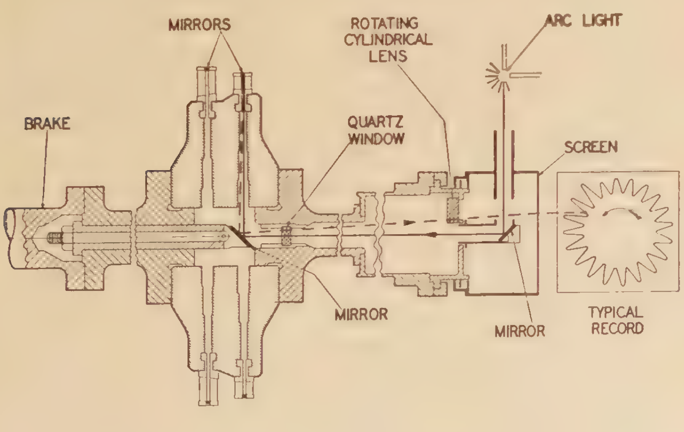
1. Transient Electric Currents (a book), W. T. Skilling. McGraw-Hill Book Company, New York, N. Y., 1937, pages 331–7.

2. Astronomy (a book), H. H. Skilling and Richardson. Henry Holt and Company, New York, N. Y., 1939, figure 67, page 118.

Blade Vibration Viewed in Experimental Turbine

SOME of the difficulties experienced with early superposed steam-electric turbogenerator units indicated a need for a better understanding of the conditions affecting the operation of turbine impulse blades in these machines. To obtain good economy at partial loads the incoming steam is fed to the first turbine wheel at only a portion of its periphery, and the blades passing into and out of this steam jet receive a most violent shock each revolution of the turbine. This method of loading has been used for many years with turbines operating at lower pressures, and it has been only on those few machines of the large superposed class, which operate at a pressure of approximately 1,200 pounds per square inch and a temperature of some 900 degrees Fahrenheit, that its use has caused some blades to break at the root where they are fastened to the spindle.

To enable the behavior of the turbine blades to be studied directly, an ingenious optical method has been devised whereby engineers literally can see inside the tur-



bine while it is running and observe the vibration of the blades. As shown by the accompanying diagram, tiny mirrors are mounted inside the blades. A light beam projected through a hole in the turbine shaft is reflected by an inclined mirror through a hole in the spindle and blade to the mirror in the whirling blade being studied, and then back out through the shaft to a stationary camera or viewing screen. By taking pictures at short intervals on moving film, an exact record of blade performance may be obtained for any desired set of operating conditions. As may be seen by the typical record at the right of the diagram, the vibration of the blade is indicated by the oscillation of the light spot reflected back from the turbine blade around a circular path; if there were no vibration, the pattern would be a perfect circle.

Since September 1939, an experimental turbine of this type, built by the Westinghouse Electric and Manufacturing Company, has been under test in the South Philadelphia works of that company. More than 20,000 photographic records have been obtained showing the performance of impulse blades for a wide range of operating conditions. This machine operates at a pressure of 400 pounds per square inch and a temperature of 600 degrees Fahrenheit.

Studies so far show that the amount of load on a turbine has relatively little effect on the maximum blade stress. The factors that influence this condition are mechanical resonance and the damping characteristics of the bladesteel. It has been demonstrated that the impulse blading of large superposed turbines must be designed to operate at safe stresses under resonant conditions. The damping characteristics of different steels vary widely. The widely used 12-per cent chrome steel has more damping in its usable application range than any other material yet investigated. The materials of the chrome nickel class that excel in high strength at high temperatures have about one-tenth as much damping as the 12-per cent chrome steel. Damping becomes less as the frequency of vibration increases. This means that the increased stiffness of heavier blades does not result in much lower blade stresses. Damping decreases rapidly at higher operating temperatures, particularly beyond 750 degrees Fahrenheit.

The successful results obtained with the first machine has led to the design and construction of a larger experimental turbine by the Westinghouse company. This machine contains a full-size impulse wheel that is a duplicate of the first impulse stage of a 50,000-kw superposed unit and operates at a pressure of 1,250 pounds per square inch and a temperature of 900 degrees Fahrenheit. This turbine with its 10,000-kw generator and 15,000-horsepower water brake began testing operations in February in the Schuylkill plant of the Philadelphia Electric Company. The turbine takes steam from the station high-pressure steam lines and exhausts into the low-pressure lines permitting its operation as a superposed unit without interference with the station's regular operation. This turbine is built solely for research purposes and has many constructional features. The optical system will record the performance of 16 different blade combinations. Two rotors are being built with different blade designs. The use of the 10,000-kw generator will permit life tests on turbine blading by loading into the Philadelphia Electric system.

Revision of Electrical Units

E. C. CRITTENDEN
MEMBER AIEE

The international situation necessitated that the adoption of certain changes in electrical units which was to have taken place January 1, 1940, be indefinitely postponed. This article outlines the existing status of the changes, and also endeavors to clarify the proposed "mks" system of practical units, adoption of which has been advocated by the International Electrotechnical Commission. In addition, certain other proposals for adjustment of units are discussed.

ALTHOUGH world-wide agreement upon a system of practical electrical units was obtained many years ago, several different systems of units have remained in use for different purposes. Naturally some confusion has resulted from this diversity, and in recent years various proposals to bring about a closer approach to uniformity of practice have been seriously considered. In fact, so many such proposals, varying in details, have been made that they have caused further confusion of ideas. It has therefore been suggested that a simple statement of the more important projects for adjustment of the units would be useful. In such a statement it is not practicable to mention all the possible solutions that have been proposed, or to give credit to the individuals who have helped to clarify the problem. As a background, however, it appears necessary to review in part the history of our present common units.

THE INTERNATIONAL ELECTRICAL UNITS

The present international system of electrical units is the result of many compromises. The approximate magnitudes of the units came historically from units of resistance and electromotive force that had come into use because of their convenient size before any general system was accepted. Their exact magnitudes, however, were adjusted from time to time to make them consistent with the centimeter-gram-second (cgs) electromagnetic system; that is, the ohm was made as nearly as possible 10^9 cgs units, the volt 10^8 cgs units. A succession of International Electrical Congresses (1881, 1889, and 1893) developed definitions of the various units in which the cgs electromagnetic system was recognized as fundamental, but the ohm, ampere, and volt, respectively, were represented by specified physical standards (mercury column, silver voltameter, and Clark standard cell). After the Chicago Congress of 1893 a number of countries established by law units based upon the definitions adopted by that Congress. In the United States this was done by the Act of July 12, 1894.[1]

The resolutions of the Electrical Congresses and the United States law were formulated with the idea that there were no essential differences between the units represented by the physical standards and the corresponding multiples of the cgs units; and no clear distinction was made between the two systems. Such a distinction was made, however, by an official International Conference on Electrical Units and Standards held in London in 1908. It was then known that there were appreciable differences between the two systems; by a divided vote the Conference decided to retain the values represented by two of the physical standards, these being the mercury column for the ohm, and the silver voltameter for the ampere. The magnitude of the volt was to be determined in accordance with Ohm's law; this was done by an international technical committee in Washington in 1910, and the result was expressed by assigning a numerical value (1.0183 "international volts") for the electromotive force of the average Weston normal cell. At the same time there was adopted an "international ohm" as determined by measurements with mercury columns made at the national laboratories of Germany and Great Britain. In actual practice the two units then adopted have been the basis of practically all "international" units used since 1911.[2]

While the international units have been retained, the basis on which they were established has been practically abandoned. The mercury column and the silver voltameter were adopted as primary standards with the idea that any laboratory that chose to do so could reproduce them and thereby reproduce the units. In most of the larger countries, however, there are now national laboratories charged with the maintenance of standards, and other laboratories depend entirely upon them for the fundamental measurements. Furthermore, improved standard resistors and standard cells have shown such constancy of values that the units evidently can be maintained with them over periods of many years with far greater certainty than they could be reproduced by means of the primary standards. Consequently few observations have been made on mercury ohm columns or silver voltameters in the last 25 years, and in only one or two instances have the units in actual use been changed as a result of such reference to the primary standards.

In the meantime measurements made by "absolute" methods (that is, by reference to the fundamental mechanical units) showed definitely that the international ohm is about $^1/_{20}$ of one per cent larger than 10^9 cgs units of resistance,[3,4,5,6] while the international ampere is apparently $^1/_{100}$ of one per cent smaller than $^1/_{10}$ cgs unit of current.[7,8] The international volt and watt are there-

E. C. CRITTENDEN is chief of the electrical division, National Bureau of Standards, Washington, D. C.

1. For all numbered references, see list at end of article.

fore larger than the corresponding absolute units by about 0.04 and 0.03 per cent, respectively.

PROPOSED ADJUSTMENT OF UNITS—THE ABSOLUTE SYSTEM

Although there had been various proposals to establish a permanent international body to deal with electrical units, none had been formed up to 1921. A treaty signed in 1921 by representatives of the United States and 26 other countries and ratified in 1923[9] gave responsibility for those units to the existing organization for weights and measures. This organization consisted of the General Conference, a diplomatic assembly meeting at six-year intervals, the International Committee of 18 members elected as individuals, which meets at two-year intervals, and the International Bureau of Weights and Measures, a laboratory at Sèvres, near Paris. In order to fulfill its new responsibilities the General Conference of 1927 created a new branch of the organization, an Advisory Committee on Electricity with 10 members, including ex-officio representatives of six of the larger national laboratories.

The first problem before the new committee was to determine whether the international system of units should be maintained and perfected or whether the electrical units should be adjusted in some way to make them concordant with mechanical units. In anticipation of international action, the National Bureau of Standards put this question before American organizations, especially the AIEE.[10] After discussion in appropriate committees a resolution was passed by the board of directors of the Institute in June 1928, urging that researches be undertaken "in order that the absolute ohm and absolute ampere based on the centimeter-gram-second electromagnetic system, with the absolute volt, watt, and other units derived from them, may be legalized in place of the international ohm and ampere and their derived units." During the same year, at the request of the National Bureau of Standards, all the major American scientific and technical societies interested in electrical measurements appointed representatives on a special committee to consider this question, and this committee unanimously adopted a similar, but less specific, recommendation.

These American recommendations were unanimously accepted by the international Advisory Committee on Electricity at its first meeting in November 1928, and by the International Committee on Weights and Measures in 1929. The next General Conference (1933), at which 29 countries were represented, approved in principle the adoption of the absolute units and authorized the International Committee to fix a date for their introduction.

In 1935 the International Committee decided that all absolute measurements to be considered in establishing the units should be reported by the end of 1938 and that the new values of the units should be put into use January 1, 1940. In 1937 results reported by four national laboratories were sufficiently concordant so that the International Committee felt justified in publishing an estimate of the probable ratios of the old to the new units, carried to five decimal places, as follows:[11]

1 mean international ohm = 1.00048 absolute ohms
1 mean international volt = 1.00036 absolute volts

The first ratio was believed to be correct within two or three units in the last place given, but the uncertainty in the volt was greater.

The program laid out by the International Committee was not carried out because the German national laboratory, the Physikalisch-Technische Reichsanstalt, had not completed its absolute measurements in 1938 and the German authorities were not prepared to adopt the absolute units until the Reichsanstalt had itself determined their magnitudes. For the ohm the German values were in good agreement with those found in other countries, but there were differences in the absolute measurement of current from which the volt would be derived. The preliminary results of the Reichsanstalt indicated that the absolute ampere was at least one part in 10,000 smaller than had been found in other countries. Consequently the Advisory Committee on Electricity, which met in June 1939, was not able to assign precise values for standards in terms of the absolute units nor to agree upon a definite date when this could be done. The apparatus used in the Reichsanstalt measurements was practically a duplicate of the current balance used at the National Bureau of Standards; plans were therefore made to exchange coils and to compare details of procedure at the two institutions in order to find the cause of the discrepancy between results.

There was also some hope that the German authorities might agree to join in establishing units fixed by rounding off the mean of the determinations to parts in 10,000, leaving them subject to future adjustment of some parts in 100,000. This would make the ratios of the international to the new units 1.00050 for the ohm and 1.00040 for the volt.

These proposals were to have been taken up at meetings of the International Committee and the General Conference in October 1939, but the meetings were cancelled when war broke out. A change in units should be made only by common action of all important countries, and no further progress toward agreement can be made until peace is restored.

It may be observed that the changes proposed are merely adjustments of the ordinary, or practical, electrical units to make them concordant with the fundamental mechanical units, and the change in magnitude would not be greater than $^1/_{20}$ of one per cent for any unit.

The international bodies concerned have not prescribed any specific methods for carrying out the "absolute" measurements by which the electrical units are to be derived from the mechanical units. In fact, it is clearly understood that the use of different methods and apparatus is desirable in order to reduce the effect of systematic errors which might exist in any one method. The absolute measurements may be made by any method in accordance with the generally accepted principles of electromagnetism. The reference to the centimeter-gram-second system of units is immaterial so far as the magnitude of the mechanical units is concerned. The essential point is that, in addition to the mechanical units, some electromagnetic unit or constant must be used; in the cgs electromagnetic system this is supplied by taking the permeability of space (μ_0) as unity.

With regard to maintenance of the units for the periods

between redeterminations by fundamental measurements no essential change would be made from the present practice. Groups of standard resistors and of standard cells would still be used as the principal means of keeping constant values for the ohm and the volt in the national laboratories, and also the means of providing basic standards for other laboratories. Incidentally, in view of the frequent reference made to the ohm as a basic unit, it should be noted that, in the absolute measurements made up to the present time, both the ohm and the volt are secondary or derived units, because the electrical quantities actually determined by direct application of mechanical measurements are inductance and current.

THE METER-KILOGRAM-SECOND SYSTEM

While it is proposed to adjust the values of the electrical units as indicated above, the practical system is so firmly established that no proposal to change it radically can be considered. On the contrary, serious proposals have been made to extend the use of that system and to bring other units into concordance with it. In particular the continued use of the cgs system has been condemned, one reason being that a variety of powers of ten are required to convert from cgs electrical units to practical units.

If the second is retained as the unit of time, there are an infinite number of combinations of units of length and mass that will make equations including mechanical units concordant (or coherent) with the practical electrical system, all the necessary powers of ten being lumped into the value assigned for the permeability of space (μ_0). It happens that one of these combinations includes the two units, meter and kilogram, which are the real bases of the metric system. Consequently, if we use meters and kilograms instead of centimeters and grams in the fundamental electromagnetic definitions and equations, the ordinary units can be used for all the electrical quantities, provided that μ_0, with the numerical value 10^{-7}, is put in where it belongs. The use of the meter-kilogram-second system therefore involves no change whatever in the ordinary electrical units, if one disregards the small difference between international and absolute units, as is usually done in textbooks and theoretical discussions.

The introduction of mks units, however, radically changes the common usages in other fields, especially magnetism, where the cgs units are now largely used. It also makes necessary some new mechanical units, including a unit of force equal to 10^5 dynes, for which the name "newton" has been proposed.

Furthermore, there are several possible varieties of mks systems, one exactly analogous to the cgs electromagnetic system and others "rationalized". "Rationalization" means defining the units in such a way as to shift the factor 4π, which inevitably appears in some of the equations, to places that are believed to be more logical and convenient. Various methods of doing this have been proposed.[12,13,14,15,16] The International Electrotechnical Commission at its sessions of 1935[17] and 1938[11] "adopted" the mks system without reaching a decision on the question of rationalization, but the trend of practice among writers and teachers who have actually used the system seems to be definitely in favor of a rationalized system in which μ_0 is taken as $4\pi \cdot 10^{-7}$ instead of 10^{-7}, and the unit of magnetomotive force is the ampere-turn instead of the ampere-turn/4π.[18]

The IEC has no authority to require anyone to use the mks system. The "adoption" of the system is in effect simply a recommendation that it be used. At least one textbook using mks units has already been published;[19] and the system is being introduced into various college courses. If usage can be concentrated on some one mks system a very desirable simplification may result, even if the system is not accepted for all fields of work. It is not to be expected that the mks system will completely displace the cgs systems.

OTHER PROPOSED ADJUSTMENTS OF UNITS

The discovery that the electrical and the mechanical units could be so conveniently connected by using the meter and kilogram as indicated above was made by Professor G. Giorgi[20] of Italy, and in recognition of this contribution the IEC proposes to call the system the Giorgi MKS system. Giorgi's plan, however, went further than this. Giorgi's system was rationalized. Furthermore, instead of taking a value of permeability as the means of connecting the mechanical and electrical quantities, he took the ohm as a fourth fundamental unit. When it developed that the international ohm differed by a significant amount from the absolute ohm (10^9 cgs units), it was pointed out that the international ohm might be retained and the "MKSΩ" system (mechanical and electrical) could be made consistent by adjusting the other electrical units.[21] In Giorgi's system μ_0, instead of being taken as exactly $4\pi \cdot 10^{-7}$, would be an empirical constant. The numerical value of μ_0 would be determined by the same absolute measurements that are now being made to fix the size of the absolute units. Those measurements would also determine the changes necessary in other electrical units; such changes would in general be smaller than the change now proposed for the ohm.

When the IEC voted in 1935 to adopt the mks system there was considerable confusion with regard to the meaning of this action, since in fact the IEC has no authority to change the fundamental units. There was also some difference of opinion as to whether, for the purposes of the IEC, Giorgi's choice of the ohm as a basic unit was the best. Consequently the IEC asked the advice of other bodies with regard to the choice of a fourth unit, meaning to choose some one of the practical electrical units.

In the discussion regarding the "fourth unit" several different problems were confused. Besides the fundamental question of the basis to be adopted for determining the size of the units, arguments were advanced regarding the standards to represent the units in the laboratory, the choice of units to give convenient dimensional equations, and the sequence in which the units could most conveniently be defined. It appeared that for these different purposes different units might be selected as starting points for a system, and it was not clear which of these purposes the IEC committees had in mind. However, nearly everyone agreed that the basis for fixing the size of the units should be the electromagnetic system, and not any one of the

electrical units; that is, a value for μ_0 should be specified, and this value should be equivalent to the value $\mu_0=1$ for the cgs system. In 1938 the IEC decided to follow this advice, thus concurring with the decision previously made by the International Committee on Weights and Measures.

The decision that no one of the electrical units is to be arbitrarily chosen as a datum from which the magnitudes of other units and their correlating constants are to be derived need not prevent anyone from choosing any convenient set of units as a base for other purposes. The whole system of units is intended to be consistent, and no contradictions should result from starting at different points in it. For example, the practicable methods of obtaining electrical units precisely from mechanical measurements involve use of two electrical quantities (inductance and current) instead of only one, with the corollary that precise values of the watt or joule, instead of being obtained by application of the mechanical definitions, are always obtained from electrical measurements. The practicable methods of maintaining units precisely and of transferring them from one laboratory to another involve two other units, ohm and volt. Dimensions of quantities are not fundamental,[22,23,24] and there appears to be no reason why a writer may not choose as a basis for them any quantities which he finds convenient. Formal definitions cannot be made to accord with the actual procedure of setting up the units without making them excessively complex; it seems therefore reasonable to set up a series of definitions starting with any convenient unit.

CONCLUSION

The decision made by the official international organizations dealing with weights and measures to adopt the absolute practical electrical units in place of the present international units on January 1, 1940, could not be carried out on that date because agreement had not been reached on exact values for the absolute units. It is, however, quite certain that the change in the ohm will be a decrease of about 48 parts in 100,000; the volt will probably be decreased by 35 to 40 parts in 100,000; adjustments of other units follow from these two changes. Further comparisons of standards between the various national laboratories will be necessary before exact values can be established and a new date fixed for the change in units; such co-operative work cannot be carried on during the war, and consequently it is not now possible to say when the change will be made.

The action taken by the International Electrotechnical Commission in 1935 and 1938 in adopting or recommending the meter-kilogram-second system of units is only indirectly related to the adjustment of the magnitudes of the units. The use of the mks system involves no change in the practical electrical units, but its magnetic units differ from those commonly used. The IEC left to the future a decision between alternative locations for the factor 4π, which will affect the magnetic units. Many authorities, however, favor a rationalized system which makes the permeability of space $\mu_0=4\pi\cdot 10^{-7}$ and the unit of magnetomotive force the ampere-turn. The mks system also introduces new mechanical units, including the "newton" which is equal to 10^5 dynes.

While the complete mks system advocated by the IEC applies precisely only when the absolute electrical units are used, this need not prevent its adoption in practice, since allowance can be made when necessary for the difference between absolute and international units, just as is done with other systems.

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Of Current Interest

Other Societies

NRC Committee to Survey Research in Industry

At the request of the National Resources Planning Board (formerly the National Resources Committee) the National Research Council has undertaken a survey of the scientific research carried on by industry in the United States. The study is part of the Planning Board's program of evaluating the country's facilities for scientific work.

The report by the NRC will emphasize significant trends in the development of research by industry, the direct application of scientific knowledge to manufacture, the relation of research to the growth of various industries, and will also include a comparison of industrial research abroad with that in the United States. The NRC Directory of Industrial Research Laboratories, now in its sixth edition, will be revised completely in connection with the survey.

The NRC committee in charge of the survey includes the following AIEE members:

O. E. Buckley (M'19, F'29) executive vice-president, Bell Telephone Laboratories, Inc., New York, N. Y.

W. D. Coolidge (A'10, M'34) director of research, General Electric Company, Schenectady, N. Y.

Maurice Holland (A'23, M'30) director, division of engineering and industrial research, National Research Council, New York, N. Y.

F. B. Jewett (A'03, F'12) vice-president, American Telephone and Telegraph Company, New York, N. Y.

Future Meetings of Other Societies

American Institute of Chemical Engineers. 32d semiannual meeting, May 13–15, 1940, Buffalo, N. Y.

American Physical Society. 234th meeting, April 25–27, 1940, Washington, D. C.

235th meeting, June 19–20, 1940, Seattle, Wash.

236th meeting, June 20–22, 1940, Pittsburgh, Pa.

American Society for Testing Materials. 43d annual meeting, June 24–28, 1940, Atlantic City, N. J.

American Society of Civil Engineers. Spring meeting, April 17–19, 1940, Kansas City, Mo.

Annual convention, July 24–26, 1940, Denver, Colo.

American Society of Heating and Ventilating Engineers. Semiannual meeting, June 17–19, 1940, Washington, D. C.

American Society of Mechanical Engineers. Spring meeting, May 1–3, 1940, Worcester, Mass.

Semiannual meeting, June 17–21, 1940, Milwaukee, Wis.

Edison Electric Institute. Annual meeting, June 3–6, 1940, Atlantic City, N. J.

Electrochemical Society. Spring meeting, April 24–27, 1940, Wernersville, Pa.

National Electrical Manufacturers Association. May 14–17, 1940, Hot Springs, Va.

National Fire Protection Association. Annual meeting, May 6–11, 1940, Atlantic City, N. J.

Society for the Promotion of Engineering Education. 48th annual meeting, June 24–28, 1940, University of California, Berkeley, Calif.

Society of Automotive Engineers. Summer meeting, June 9–14, 1940, White Sulphur Springs, W. Va.

U. S. Committee, ICI, to Maintain Organization

Although the work of the International Commission on Illumination has been interrupted for an indefinite period by the war in Europe, the United States National Committee of the Commission proposes to maintain its organization, in order to resume activities as soon as the international situation permits, according to the report of the president for the year ending with October 1939. Expenses of the Committee in the meantime will be kept at a minimum, and only nominal dues collected. Constituent organizations are being urged to continue their participation by payment of such dues and appointment of representatives.

As publication of the proceedings of the tenth international sessions of the Commission, held in Holland June 10–21, 1939, is likely to be delayed by the war, a detailed report of the meetings has been prepared by the executive secretary of the United States National Committee and will be given considerable circulation, the president's report states.

AIChE Moves to New Quarters. Because of its growth in membership, the American Institute of Chemical Engineers moved its offices on April 1, 1940, from the Engineering Societies Building to the Chemists' Building, 50 East 41st Street, New York, N. Y. Membership in the society has increased from about 1,500 to 2,400 in the last three years. All activities connected with the publication of the *Transactions* will take place at the new offices.

Honors

Washington Award Announced for 1940

The Washington Award "in recognition of pre-eminent service in advancing human progress" has been conferred for 1940 upon Daniel Cowan Jackling, "for pioneering in large-scale mining and treatment of low-grade copper ores, releasing vast resources from formerly worthless deposits." Doctor Jackling, who is president of the Utah Copper Company, San Francisco, Calif., and a past president of the American Institute of Mining and Metallurgical Engineers, demonstrated the possibility of profitable exploitation of low-grade porphyry orebodies and was active in the formation of the Utah company to develop such ores. Among improvements in mining operations for which he was responsible have been the use of electric shovels for digging, steel construction in mill buildings, and three-phase alternating current in connection with hydroelectric developments. He received the John Fritz Medal in 1933.

A bronze plaque symbolizing the award will be presented to Doctor Jackling on April 15. He is the 17th engineer to receive the Washington Award since it was founded in 1916. Administered by the Western Society of Engineers in co-operation with the American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, and AIEE, the award is made annually, provided the members of the commission agree upon a deserving candidate.

Faraday Medal Awarded for 1939

The Faraday Medal, highest honor of the Institution of Electrical Engineers of Great Britain, was awarded for 1939 to Doctor Alexander Russell, past president of the Institution. Author of a life of Lord Kelvin and other works on physics and engineering, Doctor Russell is the 18th recipient of the award, which is bestowed for notable scientific and industrial achievement in electrical engineering or conspicuous service to the advancement of electrical science, without restriction as to nationality, residence, or membership in the society. Nine of the 18 recipients have been members of the AIEE, and three of these were Americans: Elihu Thomson, 1927; F. B. Jewett, 1934; and W. D. Coolidge, 1938.

Education

Stevens Revises Courses. The junior laboratory course in electrical engineering presented at Stevens Institute of Technology is being revised with the assistance of a specially selected group of 24 members of the junior class. The group is working under direction on the development of 12 new experiments planned to broaden the department's curriculum for the junior and senior years. Lecture and laboratory courses in electrical engineering are required of all Stevens undergraduates. Much of the work formerly given juniors is now included in freshmen and sophomore courses under the physics department; the junior lecture course has been broadened to include study of a-c circuits and machinery,

formerly given to seniors; and the senior curriculum now provides more work than before in communications and electronics.

Short Management Course. A three-week course on motion and time study and related problems for executives, industrial engineers, cost accountants, and others, is being presented at the University of Iowa, Iowa City, June 10–28, 1940. Given last year for the first time, the summer management course is under the direction of Ralph M. Barnes, professor of industrial engineering, assisted by seven members of the University faculty. Visiting engineers and managers from industry will conduct forums on practical production problems.

Industry • • • •

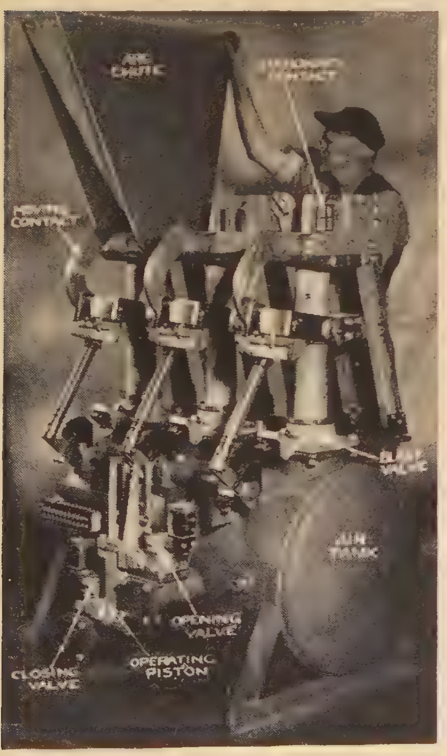
Compressed-Air Circuit Breaker Given Demonstration Tests

A compressed-air circuit breaker developed by Westinghouse Electric and Manufacturing Company was given demonstration tests at the company's laboratory at East Pittsburgh, Pa., March 5, 1940, before more than 200 utility and industrial engineers.

The newly developed breaker was tested on power interruptions ranging from normal load current of 2,000 amperes at 13,200 volts to the three-phase 1,500,000-kva short-circuit capacity of the laboratory. Oscillograms made during the demonstration were said to show that all currents were interrupted at the first current zero, with about one-half cycle of arcing. No transient voltage greater than twice normal was observed.

The interrupting element of the compressed-air circuit breaker uses a cross blast of compressed air that passes between separated contacts in such a manner that the arc is driven against insulating splitter plates. By the time a current zero is reached an intense diffusive effect has de-ionized the arc space rapidly, causing the arc to be interrupted.

The demonstration included dismantling of the breaker to show the small amount of wear resulting from a series of operations. The component parts of the new unit are shown in the illustration.



All-Electric Streamliners. The Chicago, North Shore, and Milwaukee Railroad has ordered two all-electric streamlined passenger trains for high-speed operation between Chicago and Milwaukee. Believed to be the first of their kind to be put in use in the United States, each of the two complete four-car units will weigh light approximately 160,000 pounds, will be about 157 feet long, and will be capable of operating with the maximum load of 133 passengers at 80 miles per hour speed on 550 volts. Each unit will be powered with eight 125-horsepower 300-volt motors. Electric-pneumatic unit-switch control will provide for operation from either end of the four-car unit. The trains will be completely air-conditioned.

Television. A textbook on "Television—Electronics of Image Transmission," by V. K. Zworykin and G. A. Morton, has been published by John Wiley and Sons, Inc., New York, N. Y. Four major divisions, comprising more than 600 pages, treat the fundamental physical principles, the principles of television, the component elements of an electronic television system, and the RCA-NBC television project. Construction data for an experimental receiver are given. For those having access to laboratories, the description of apparatus has been made sufficiently complete to permit the construction of working models of pickup and viewing tubes in an elementary form. The book is priced at $6.

New Type Copper Introduced. Phelps Dodge Copper Products Corporation has announced the production of a new type of copper designed to eliminate the cause of 75 per cent of electrical failures, according to the company. Said to be almost as malleable as gold, the improved metal is made without melting from electrolytic cathode copper, plastically converted to commercial shapes at great pressure in a reducing atmosphere at high temperatures. It will be produced at a new plant at Bayway, N. J., and is expected to be particularly useful in airplane, submarine, and electric-locomotive power plants, the announcement states.

Tool Electrification Forum. The 1940 Machine Tool Electrification Forum will be held at the East Pittsburgh, Pa., works of the Westinghouse Electric and Manufacturing Company, May 6–8, 1940. Originally scheduled for April 29 to May 1, the dates of the forum have been changed to avoid conflict with other industrial meetings.

From A E C • •

ITEMS appearing under this heading are from the news service of American Engineering Council.

Supreme Court to Review Federal Rule Over Power

The much-disputed question of how far up the tributaries of navigable streams the Federal Government can constitutionally extend its authority has at last reached the Supreme Court of the United States, which on March 4 agreed to review lower-court decisions regarding the necessity for a Federal Power Commission license for the $11,000,000 hydroelectric development of the Appalachian Power Company on the New River at Radford, Va.

This case has had a tangled legal history extending over the last 15 years, during which the plant has been built and placed in operation. The power company has consistently refused to apply for a Federal license on the ground that the New River is not navigable and Federal jurisdiction does not apply. The Government contends that the New River is legally a navigable stream and that, furthermore, the project will affect navigation on the Kanawha River, into which it flows, and the Ohio River farther down. It asks an injunction prohibiting operation of the plant until a license is applied for and granted.

A ruling that the plant requires a license will subject the power company to certain requirements regarding operation of the plant, and will also mean that it can be recaptured by the Government at the end of 50 years.

Meanwhile Governor Leon C. Phillips of Oklahoma, who recently was refused permission by the Supreme Court to bring a suit to enjoin the construction by the Federal Government of Denison Dam on the Red River between Oklahoma and Texas, opened up a new battle by declaring that he would use troops, if necessary, to prevent the flooding of state roads and bridges due to the imminent completion of the Grand River Dam, a PWA-financed project being built by a state-created authority.

Engineering Projects Curtailed

Continuation of the drive by Congress to reduce below budget recommendations appropriations for the fiscal year beginning July 1, 1940, has resulted in a number of cuts affecting engineering work of various kinds.

The War Department appropriation bill for nonmilitary activities was reported to the House of Representatives only after its appropriations committee had eliminated a $15,000,000 item to begin the construction of a third set of locks for the Panama Canal. In its plan the committee recommended $850,000 for the preparation of plans and specifications, stating that to begin construction at present would be "premature." This action was upheld by the House itself in passing the bill.

Also eliminated from the bill was $800,000 for dredging a channel at Wake Island in the Pacific Ocean. As passed by the House,

the measure appropriated $70,000,000 for general flood control, or $63,000,000 less than the appropriation for the current year; $30,000,000 for flood control on the lower Mississippi River, a cut of $9,000,000; and $66,721,510 for river and harbor improvements, or nearly $30,000,000 below the current level. Also approved was $30,098,771 for work on the Panama Canal not connected with the new locks, but largely designed to strengthen its defenses.

Economy also trimmed the Interior Department appropriation bill, from which the appropriations committee cut almost $3,000,000, bringing the total down to about $119,000,000 as compared with $148,000,000 appropriated last year. Specific cuts included $1,247,000 from the United States Geological Survey, principally from a proposed fund for mapping strategic areas of military importance. This item represented an attempt to procure more funds for mapping, a proposal long favored by AEC. It was ruled out on the ground that an expenditure for military purposes should not be included in the Interior Department bill.

Library

OPERATED jointly by the AIEE and the other founder societies, the Engineering Societies Library, 29 West 39th Street, New York, N. Y., offers a wide variety of services to members all over the world. Information about these services may be obtained on inquiry to the director.

New Rules for Lending Books

With the object of making the Engineering Societies Library more useful to members, especially those prevented by distance from calling at the building, the library board has adopted the following rules for lending books:

1. Volumes from the library's general collection will be lent only to members in good standing of the founder societies and to nonprivate and noncommercial libraries. Volumes from the duplicate collection will be lent to any person establishing his responsible character to the satisfaction of the director.

2. Volumes declared by the director to be rare books or reference books will be lent only after approval by the executive committee.

3. Serial publications will be lent only after they have been bound.

4. A minimum charge of 50 cents per volume, which includes expense for insurance and postage to the borrower, will be made to all persons.

5. For each volume retained by the borrower longer than one week, a rental of 5 cents per day will be charged.

6. No volume from the library's general collection will be lent for a period longer than ten days, plus time for transit to and from the borrower, except with the specific approval of the executive committee.

7. No individual may have more than three volumes on loan in his name at any one time, and no library may have more than five volumes on loan in its name at any one time.

8. No loans will be made outside the continental United States and Canada.

It should be noted that while only members of the American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, and AIEE may borrow books from the general collection, responsible nonmembers as well as members of the societies may borrow books from the duplicate collection. Bound volumes of periodicals are usually available for loan about two months after completion of the volume of the publication in question. The minimum charge of 50 cents per volume on loans is required from the local borrower who comes to the library in person, as well as from the borrower who uses the mails. Return mailing costs are paid by the borrower. The time in transit is not included in the length of time borrowers may retain books without additional charge (see 5).

Requests for loans should be addressed to the Engineering Societies Library, 29 West 39th Street, New York, N. Y. Members are asked to give their society affiliations when writing about loans.

Copies of Articles

Beginning March 1, the price of photostats is changed to 30 cents, including postage. Members of the founder societies can obtain a discount of 5 cents a print on personal orders, by mentioning the society to which they belong.

This price is for 11- by 14-inch white-on-black (negative) prints on bromide paper. Black-on-white (positive) prints can also be supplied by copying a negative print. These cost 30 cents in addition to the cost of the negative.

The prints contain one or two pages of the original paper, depending on its size. Reductions to approximately one-half or enlargements to approximately twice the original can be made, if desired, without extra cost. Unless enlargement or reduction is ordered, prints will be made the same size as the original.

Microfilm copies, on 35-millimeter film can also be supplied at a cost of 4 cents per exposure (usually one page), with a minimum charge of $1.25 per volume or piece.

For obvious reasons, copying is confined to library property. Where the library lacks what is wanted, it will arrange to get copies for members from other libraries or refer them to places where copies can be had.

MEMBERS MAY MAKE COPIES

For the benefit of members who wish to photograph material in the Library, a copying stand is available for use with the member's own camera.

Letters to the Editor

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers; publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Currents and Voltages of a Three-Phase Unbalanced Load

To the Editor:

In a Letter to the Editor, February 1940, W. H. Huggins gives what he apparently believes is a novel approach to the unbalanced wye problem. I should like to call to his attention that his method is really nothing but Doctor Kennelly's wye-delta transformation. The method of proof that he uses works as easily on the n-point star as on the three-point and is practically the standard method of proof. (See "Electric Circuits and Wave Filters", A. T. Starr, page 80.)

If one assumes that it is known that the equivalent electromotive force of a group of alternators in parallel is $E' = \Sigma yE/\Sigma y$

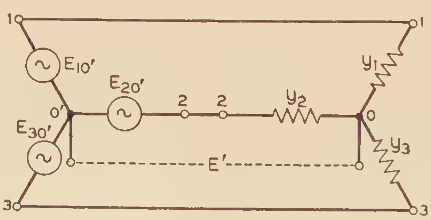


Figure 1

the results follow immediately as shown in figure 1.

The voltage

$$E' = E_{00}' = \frac{y_1E_{10}' + y_2E_{20}' + y_3E_{30}'}{y_1 + y_2 + y_3}$$

If now we let E_{10}' become zero, so that 0′ coincides with 1, and E_{20}' and E_{30}' become E_{21} and E_{31}, respectively, we have

$$E' = E_{00}' = E_{01} = \frac{0 + y_2E_{21} + y_3E_{31}}{\Sigma y}$$

or, reversing the voltage subscripts,

$$E_{10} = \frac{y_2E_{12} + y_3E_{13}}{\Sigma y}$$

$$I_1 = \frac{y_1y_2}{\Sigma y}E_{12} + \frac{y_1y_3}{\Sigma y}E_{13}$$

The other voltages and currents follow by cyclic order.

This method also works for an n-point star and, assuming the knowledge of alternators in parallel or Thevenin's Theorem, of which it is a particular case, is very brief.

V. G. Smith (A'26, M'35)

(Associate professor of electrical engineering, University of Toronto, Toronto, Ont., Can.)

To the Editor:

In his letter to Electrical Engineering, February 1940 issue, Mr. Huggins indicates a novel method of solving an unbalanced wye circuit. His solution, however, is only a corollary of the more general solution of the m-phase, star-connected system with a neutral return which was first developed by Professor Karapetoff. Since then, numerous variations have been made, of which Mr. Huggins' solution is one.

The basis of Professor Karapetoff's solution is the neutral-neutral voltage of which Mr. Huggins says "... has but little meaning for unbalanced line voltages and is difficult to determine." The neutral-neutral voltage, or voltage residual, is the voltage between the neutral of the load and the neutral of the supply lines.

Professor Karapetoff's solution is given herewith. It was taken from the discussion of the article listed at the end of this letter. I have taken the liberty of adding another step to include the effect of the neutral return.

Let us consider the m-phase, star-connected, unbalanced load with a neutral return of admittance Y_N. Let E_{ON} be the voltage between the neutral of the line voltage O, and the neutral of the load N. Assuming all directions of current flow toward the load, then

$$\left.\begin{aligned} I_1 &= Y_1(E_{10} + E_{ON}) \\ I_2 &= Y_2(E_{20} + E_{ON}) \\ &\cdots\cdots\cdots\cdots \\ I_M &= Y_M(E_{MO} + E_{ON}) \\ I_N &= Y_N E_{ON} \end{aligned}\right\} \quad (1)$$

where Y_M is the load admittance of phase M.

Remembering that $\Sigma I = 0$, we add and find

$$\left.\begin{aligned} &Y_1E_{10} + Y_2E_{20} + \ldots + Y_ME_{MO} = -E_{ON}\Sigma Y \\ &\frac{Y_1E_{10} + Y_2E_{20} + \ldots + Y_ME_{MO}}{Y_1 + Y_2 + \ldots + Y_M + Y_N} = -E_{ON} = E_{NO} \end{aligned}\right\} \quad (2)$$

This is the fundamental equation for the neutral-neutral voltage of an m-phase, star-connected system with interconnected neutrals, unbalanced supply voltages, and unbalanced loads. Substituting E_{ON} in equation 1 we may determine the desired currents and phase voltages.

Numerous particularizations may be made from these fundamental equations. Some of them are enumerated as follows:

1. The m-phase system may be reduced to the three-phase wye.

2. Unbalanced deltas may be solved by the same method, if they are first changed to unbalanced wyes.

3. The neutral return may be omitted by making $Z_{ON} = \infty$ and $Y_N = 0$.

4. The load-phase voltages may be given in terms of line voltages for a three-phase wye, thus:

with a neutral return

$$E_{1N} = \frac{E_{12}Y_2 + E_{13}Y_3 + E_{10}Y_N}{Y_1 + Y_2 + Y_3 + Y_N}$$

without a neutral return (Mr. Huggins' result)

$$E_{1N} = \frac{E_{12}Y_2 + E_{13}Y_3}{Y_1 + Y_2 + Y_3}$$

5. It may be used to check the vector wanderings of the load neutral under extreme conditions of unbalance, phase rotation, resonance, etc.

6. It may be used to solve cases of extreme unbalance such as the open delta or vee, single phase, etc.

A number of articles have been written on the possibilities of Professor Karapetoff's solution. One of them is "Floating Neutral n-Phase Systems," L. A. Doggett, AIEE TRANSACTIONS, volume 42, 1923, pages 1029–32; discussion, page 1350.

HERBERT SHERMAN (Enrolled Student)

(School of technology, College of the City of New York, New York, N.Y.)

New Indirect Luminaire Improves Drafting-Room Illumination

To the Editor:

F. P. Kuhl, in his article entitled "New Indirect Luminaire Improves Drafting-Room Illumination," (ELECTRICAL ENGINEERING, February 1940) showed one method by which a lighting installation may be improved and modernized to give better seeing conditions. As may be observed from his figures 4 and 5, the improvement in lighting was quite appreciable when the old-style milk-glass globes were replaced by specially developed louvered units utilizing 200-watt bowl silvered lamps.

It is the writer's desire to compare Mr. Kuhl's installation with one recently made in a drafting room of the American Gas and Electric Service Corporation. The latter installation made use of standard Chase Brass and Copper Company plastic bowl fixtures, bearing catalog number 1549, and utilizing 500-watt inside-frosted lamps in each unit. The spacing selected was 9 by 10 feet as determined from consideration of work- and reference-table layout and evenness of illumination upon the work plane. The fixtures were mounted with light centers 2½ feet from the ceiling and 5½ feet from the work plane. Twelve units were used in a room approximately 59 by 26 feet, so placed as to be in the center of a group of four tables consisting of two reference and two drafting tables back to back. This arrangement was the most economical one for the room and utilized the downward component of light to full advantage without causing shadows of annoying proportions. The units were selected for their efficiency and distribution characteristics, upon which preliminary design and layout calculations were performed and comparisons made with competitive units.

In comparing the two installations, one a result of specially developed lighting units and the other designed with standard economical units, the following tabulation may be helpful:

	New Louvered Unit	Standard Plastic Unit		
Lamp wattage	200*	200	300	500
Spacing	9 by 6 feet	9 by 6 feet	9 by 10 feet	9 by 10 feet
Watts per square foot	3.7	3.7	3.3	5.5
Foot-candles illumination	38**	27**	27	50
Principle of lighting	indirect	13 per cent direct; 74 per cent indirect		

* Silvered bowl lamp. ** See following discussion.

The data for the new louvered unit were taken from Mr. Kuhl's article. Utilizing these data for units placed on 9- by 6-foot spacing in the room described in the foregoing paragraph will afford a comparison with the plastic installation. Point-by-point calculations along the 6- and 9-foot spacings directly in line with the units yield illuminations varying between 27 and 34 foot-candles when all units that might contribute to that area are considered. Similar calculations on the plastic units with 200-, 300-, and 500-watt lamps yield average foot-candle values shown in the table. It is believed, therefore, that with the 9- by 6-foot spacings and 200 watts per unit the same magnitude of illumination is realized as with the new louvered fixture. The 38 foot-candles shown in the tabulation come about as a result of the contribution of other units, which would be necessary in a larger room such as that described by Mr. Kuhl.

The installation utilizing the standard plastic bowls made use of 9- by 10-foot spacing so as to minimize the number of units and therefore decrease the initial cost, as well as for the reasons previously given. With this spacing and 300-watt lamps the same magnitude of illumination may be obtained as in the previous case and with 3.3 watts per square foot, a decrease of 0.4 watts per square foot. It was felt, however, that a higher level of illumination should be maintained for the benefit of the draftsmen. This accounts for the use of 500-watt lamps and the realization of 50 foot-candles over the working plane. No part of the working area of similar height varies by more than 2 foot-candles.

This installation was made with a minimum initial investment, an item that is of importance when it is realized that the need for the installation may not exceed two years. In conclusion, therefore, it may be emphasized that:

1. Totally indirect lighting is not absolutely necessary for comfortable drafting-room lighting. Comparable shadowless lighting may be realized with semi-indirect fixtures, provided the downward component is not excessive. This installation utilized a 13 per cent downward component but it is believed that as much as 20 per cent would not prove annoying, provided the units are spaced correctly.

2. By making use of high-efficiency semi-indirect lighting units with low surface brightness, more foot-candles will be realized comfortably upon the work plane for a given initial investment and wattage per unit than will be attained with indirect units.

3. By using high-wattage lamps at greater spacings, the higher lamp efficiencies of these lamps may be incorporated into the over-all efficiency of the installation.

4. Proper control of light, such as its distribution, its result on the ceiling, on the work plane, color and level of intensity are the important features of drafting-room lighting that determine whether an installation results in comfortable shadowless glareless seeing conditions.

Thus two different attacks on the problem of drafting-room lighting have been presented. Mr. Kuhl preferred the totally indirect method utilizing a specially developed fixture. He maintains the level of illumination around 32 foot-candles. The plastic bowl installation uses a standard unit and realizes an initial average illumination of 50 foot-candles. It would be interesting to compare the economics of both installations. If both of the foregoing lighting units are considered to be equally

priced, it becomes evident that 40 per cent less would be expended initially for the plastic luminaires for equal average illumination (compare to the 300-watt lamps at 9- by 10-foot spacing). The plastic units would also require about 10 per cent less watts per square foot. In addition, by using standard lighting units, the development cost and the cost of placing the new unit into production are eliminated. The latter factors lead one to believe that the selling price of the newly developed unit would be greater than of the standard fixture, making the economy still more in favor of the standard plastic unit.

V. L. Dzwonczyk (A'36)

(Electrical engineer, American Gas and Electric Service Corporation, New York, N. Y.)

Membership Participation in AIEE Elections

To the Editor:

The letter of Paul MacGahan, printed in Electrical Engineering, February 1940, page 85, certainly should receive serious consideration by the committee on constitution and bylaws, and by the president himself. I agree with Mr. MacGahan most heartily, and suggest that headquarters do not even send out the silly ballots with the absurd provision for voting for only one person for each office, as only one name appears.

Several years ago, I observed here in our office among some 30 or 40 engineers, 10 or 15 of whom are members of the Institute, that *not a single man returned the ballot.* I took it upon myself to ask them if they had marked and sent in their ballots and they just laughed and pointed to the wastepaper baskets! So, I collected eight of these ballots and forwarded them to Headquarters, informing them that this was just a waste of money, and I did not even receive a reply.

A saving of $240 annually can be made in postage alone (16,000 at $1^1/_2$ cents) by *not* sending the useless ballots, and further savings will accrue from the elimination of printing and associated expense. President Farmer's message in the November 1939 issue makes reference to the growing demands on the Institute's financial resources. Here is an opportunity to conserve some of the resources.

I have pointed out this letter of Mr. MacGahan's to several men who have been rather prominent in Institute affairs during the past several years, and they heartily agree with my recommendation. Several of these men are ex-chairmen of the Pittsburgh Section and others have had considerable to do on national committees, particularly membership. Two members in our department here in the Duquesne Light Company brought this letter to my attention—and these are real engineers, men who have been out of school some 10, 15, or 20 years. They are still members of the Institute, however, but are not really strong members because they feel that the Institute is not on the right track.

Now I know that the constitution and bylaws cover the provision for additional nominees other than those selected by the nominating committee, but it is never done and never will be done. This is well known by the president, the nominating committee, and the officers of the Institute, and by any others who have had much to do with the Institute affairs, but I doubt if the rank and file know it—and they are the ones that support the Institute financially.

B. M. Jones (A'20, M'24)

(Division engineer, Duquesne Light Company, Pittsburgh, Pa., and chairman, membership committee, Pittsburgh Section, AIEE)

Books Received

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

THE COMPLETE WELDER. Dealing with Up-to-Date Methods of Gas and Electric Welding. Three volumes. Volume 1. Non-Electrical Methods, Design and Testing. 464 pages; Volume 2. Electric Arc Welding. 432 pages; Volume 3. Resistance Welding. 432 pages. George Newnes, Ltd., London, W. C. 2, 1939. Illustrated, $9^1/_2$ by 6 inches, cloth, £3 for three volumes. The three volumes of this set are composed of articles contributed by specialists, which are intended to cover every aspect of welding. The operation of equipment for all kinds of welding is explained, types of actual equipment on the market are described, and work under varying conditions and with different metals is discussed. All phases of the text are illustrated with photographs and diagrams. Volume III contains a classified key and an alphabetical index to the whole work, and 28 miscellaneous data sheets are contained in a separate cover.

THE ELECTRICAL YEARBOOK 1940. 33d Year. Emmott and Company, Manchester and London. 313 pages, illustrated, 7 by 4 inches, cloth, 1s.6d. Practical information and numerical data upon power-plant operation, electric motors, wiring, switchgear, metering, etc., for electrical contractors and others engaged in electrical work.

DIE ELEKTRISCHE KRAFTÜBERTRAGUNG. Volume 3. Bau und Betrieb des Kraftwerkes, Part 2. By H. Kyser and K. H. Kyser. Third edition. Julius Springer, Berlin, 1940. 616 pages, illustrated, $9^1/_2$ by 6 inches, cloth, 57 rm. The present instalment of the section in this treatise devoted to the construction and operation of power plants deals with the principles that determine the selection of continuous and a-c generators, the operation of the latter in parallel with switchgear and protective apparatus, and with the economic problems involved. The treatment is comprehensive, with emphasis upon principles rather than current forms of commercial equipment, and is intended to supply a practical text adapted to present needs. The volume completes this edition.

HIGH-SPEED DIESEL ENGINES. By P. M. Heldt. Third edition. P. M. Heldt, Nyack, N. Y., 1940. 475 pages, illustrated, $8^1/_2$ by $5^1/_2$ inches, cloth, $4.00. The purpose of this book is to discuss the principles involved in the design and operation of such engines, in the light of the research work that has been done here and abroad. Automotive, aircraft, and railroad engines are considered, with special reference to the needs of designers and experimenters. One chapter is devoted to miscellaneous types of oil engines. Differs little from the preceding edition, but contains an appendix covering the developments in research during the interval.

HOCHFREQUENZKERAMIK. (Industrielle Keramik, Volume 2.) By E. Albers-Schönberg and others. Verlag von Theodor Steinkopff, Dresden and Leipzig, 1939. 171 pages, illustrated, 9 by 6 inches, paper, 8.25 rm.; bound, 9 rm. (in USA). An account by four specialists of the properties of porcelain as an insulator in high-frequency work and of the manufacture of porcelain insulators. The raw materials, methods of working them and combining them with metal and glass, the physical properties, and use of high-frequency porcelain, and the properties and construction of porcelain high-frequency condensers are described. Each section has a brief bibliography.

INDUSTRIAL ORGANIZATION AND MANAGEMENT. By R. C. Davis. Harper and Brothers, New York and London, 1940. 636 pages, illustrated, 10 by 6 inches, cloth, $5.00. Complete revision of the author's "The Principles of Factory Organization and Management", 1928. It attempts to draw a clear picture of the fundamental functions and principles of factory organization and management and their relations to one another, with discussion of specific problems, illustrated by examples of the solutions adopted by various factories. Bibliography.

INDUSTRIAL SURVEYS AND REPORTS. By W. Rautenstrauch. John Wiley and Sons, New York; Chapman & Hall, London, 1940. 189 pages, diagrams, etc., 9 by 6 inches, cloth, $2.50. This textbook outlines some of the problems engineers encounter in investigating and reporting industrial operations. The subject matter has been evolved from business and manufacturing experience, and actual situations are presented, with field investigation required for a number of the problems. Appendix A contains a report, embodying the results of investigating a particular company, which illustrates the material discussed in the text.

INTERIOR ELECTRIC WIRING AND ESTIMATING. By A. Uhl, A. L. Nelson, and C. H. Dunlap. American Technical Society, Chicago, 1940. 342 pages, illustrated, $8^1/_2$ by $5^1/_2$ inches, cloth, $2.50. The methods, equipment, and materials for all kinds of interior wiring, from small jobs to apartment and factory buildings, are described in detail. The final chapter covers estimating electrical work, including both materials and labor costs. Eight blueprints giving the architectural drawings for a small house accompany the book.

LEGAL ASPECTS OF ENGINEERING. By W. C. Sadler. John Wiley and Sons, New York, 1940. 631 pages, 9 by 6 inches, fabrikoid, $4.00. Attempts to provide engineers with a general understanding of the legal principles that govern engineering practice and of their application by the courts. Over three hundred cases dealing with professional and industrial problems, aeronautics, property, and business, are presented.

MKS UNITS AND DIMENSIONS AND A PROPOSED MKOS SYSTEM. By G. E. M. Jauncey and A. S. Langsdorf. Macmillan Company, New York, 1940. 62 pages, diagrams, etc., 9 by 6 inches, cardboard, $1.00. In 1935 the International Electrotechnical Commission adopted the meter, kilogram, and second as the basic units of length, mass, and time, this action becoming effective in January 1940. This little book is intended to acquaint electrical engineers and physicists with the properties of this new system of basic units, to give reasons for the adoption of the ohm as the fourth basic unit, to describe a proposed meter-kilogram-second-ohm system of basic units, and to discuss the difference between magnetic flux density and magnetic field strength.

MATHEMATICAL METHODS IN ENGINEERING. By T. v. Kármán and M. A. Biot. McGraw-Hill Book Company, New York and London, 1940. 505 pages, diagrams, etc., 9 by 6 inches, cloth, $4.00. In this introduction to the mathematical treatment of engineering problems the authors present methods in connection with their practical applications in the fields of civil, mechanical, aeronautical, and electrical engineering.

PRACTICAL ELECTRIC METERING. By M. F. Smalley and others. John Wiley and Sons, New York; Chapman & Hall, London, 1940. 228 pages, diagrams, $9^1/_2$ by 6 inches, cloth, $2.75. This book, based upon lessons from a school conducted by a large operating utility company, is designed as a textbook for metermen and others interested in meters. Following a review of the fundamentals of electricity, all makes and types of electric meters are discussed, with consideration of problems arising in connection with their construction and use.

PRINCIPLES OF INDUSTRIAL MANAGEMENT FOR ENGINEERS. By L. P. Alford. Ronald Press Company, New York, 1940. 531 pages, diagrams, etc., $9^1/_2$ by 6 inches, cloth, $4.50. Presents and interprets the teachings of management as related to the present period of economic and industrial transition. The subject matter covers the evolution of industry and of management in industry, organization, and standards for the function of control, control of materials in manufacturing, time- and motion-study fundamentals, classification and cost accounting, maintenance, rate setting, wages, and industrial relations.

A TEXT BOOK ON LIGHT. By A. W. Barton. New York and London, Longmans, Green and Company, 1939. 426 pages, illustrated, 9 by 6 inches, cloth, $3.00. First treating the easily observed properties of light, then considering in detail the eye and the more important optical instruments, the book proceeds to a discussion of the theories of light, including such phenomena as interference, diffraction, polarization, etc. Illustrative examples accompany each chapter.

WHO GETS THE MONEY? By W. Rautenstrauch. Revised edition. New York and London, Harper and Brothers, 1939. 122 pages, charts, 8 by 6 inches, cloth, $1.50. In connection with an analysis of how the national income is spent, to whom it goes, and how it is used, proposals are made for a fuller application of productive capacity to the problem of feeding, clothing, and housing the 130,000,000 citizens of the United States.

Institute Activities

National

Summer Convention to Be Held at Swampscott, Mass.

The 1940 AIEE summer convention is being held at the New Ocean House, Swampscott, Mass., June 24–28. Members are reminded that, as the semi-annual meeting of The American Society of Mechanical Engineers is being held at Milwaukee, Wis., June 17–20, those traveling from the west may conveniently attend both meetings.

Tentative plans for the convention provide for a technical program of ten sessions, several technical conferences, and a general session. Arrangements have been made for a demonstration lecture on frequency modulation—the newest form of radio reception which entails a minimum of interference and noise.

The annual meeting of the Institute will be held Monday morning, June 24, followed in the afternoon by the first session of the conference of officers, delegates, and members, under the auspices of the committees on Sections and on Student Branches.

Trips to interesting places along the north shore of Massachusetts are being planned, and the bathing and sports facilities of the hotel, which are considered excellent, will be at the disposal of convention-goers. Special attention is being given to women guests.

The personnel of the summer convention committee is:

J. I. Hull, *chairman;* Thomas Cooper, Jr., and L. P. Shildneck, *vice-chairmen;* J. M. Murray, *secretary;* J. W. Lingary, *assistant secretary-treasurer;* C. L. Dawes, vice-president, North Eastern District; R. G. Lorraine, secretary-treasurer, North Eastern District; J. W. Barker, chairman, technical program committee; R. W. Adams, J. C. Balsbaugh, C. A. Corney, D. C. Jackson, H. A. McCrea, K. B. McEachron, I. E. Moultrop, F. L. Nason, J. G. Patterson, E. H. Raddin, C. F. Savage, Jr., A. C. Stevens, A. H. Sweetnam, and W. H. Timbie. *Subcommittee chairmen:* M. S. Wilson, *hotel and registration;* L. L. Edgar, *finance;* C. A. B. Halvorson, Jr., *entertainment and banquet;* I. A. Patten, *trips;* H. B. McIntyre, *sports;* G. J. Meyers, Jr., *transportation;* F. W. Bliss, *publicity;* E. A. Walker, *student activities;* Mrs. C. A. Corney, *women's entertainment.*

Executive Committee Meets

Meeting at Institute headquarters March 8, 1940, in place of the regular meeting of the board of directors, the AIEE executive committee heard a report from the special committee appointed by the board of directors to develop plans for radio talks on electrical-engineering subjects. Action was deferred to the next meeting of the board.

The committee authorized a joint session with the Institute of Radio Engineers, to be held during the Pacific Coast convention in Los Angeles, August 26–30. The dates October 9–11 were approved for the previously authorized Middle Eastern District meeting in Cincinnati, Ohio.

The following appointments were approved upon recommendation of the standards committee:

AIEE delegation, reorganized ASA sectional committee on storage batteries, C40:

C. J. Dempwolf   Ralph Seabury   H. N. Stover

Other actions included:

Approval of report of board of examiners meeting, February 21, 1940; action on recommendations as follows: 7 applicants transferred to grade of Fellow, 9 transferred and 28 elected to grade of Member, 184 elected to grade of Associate, 235 Students enrolled.

Approval of finance committee report: February disbursements $23,831.07.

Those present were:

Chairman—F. Malcolm Farmer

Members of committee—W. H. Harrison, K. B. McEachron, H. S. Osborne, John C. Parker, W. I. Slichter

Director—C. R. Beardsley

Chairman, special committee on radio talks on electrical-engineering subjects—C. R. Jones

National Secretary—H. H. Henline

District

General Committee Chosen for Middle Eastern District Meeting

Preliminary plans are in progress for the Middle Eastern District meeting at Cincinnati, Ohio, final dates for which have been set for October 9–11, 1940. The following have been appointed members of the general committee:

E. S. Fields, *chairman;* C. F. Lee, *vice-chairman. Subcommittee chairmen;* L. L. Bosch, *meetings and papers;* L. R. Culver, *student activities;* A. C. Burroway, *publicity and attendance;* J. A. Noertker, *inspection and transportation;* M. S. Schneider, *finance;* C. Fortenbaugh, *entertainment;* V. G. Rettig, *hotels and registration;* Mrs. J. A. Noertker, *women's entertainment.*

Section

Free Convention Trip for Winning Section Paper

To encourage papers by members of the Cleveland Section during 1940, Past President A. M. MacCutcheon has offered a free trip to the 1941 AIEE winter convention to the author of the best paper from a member of the Section this year. All members of the Section are eligible, except Enrolled Students in the Case School Branch, who may engage in a somewhat similar competition for the eastern division. The award defines expenses for the trip to the convention as equal to the amount allowed a Section delegate. Papers will be judged according to the rules governing National prize awards. A committee has been appointed to encourage the writing of papers and to direct their presentation.

New Section Elects Officers

At its organization meeting, held in Columbia, S. C., on March 2, the South Carolina Section (*EE, March '40, p. 130*) elected the following officers:

T. F. Ball, head of the department of electrical engineering, University of South Carolina, chairman

S. R. Rhodes, head of the department of electrical engineering, Clemson College, secretary-treasurer

Chairmen of three technical committees were appointed as follows:

Power—A. R. Wellwood, Columbia

Industrial Engineering—W. C. Boyrer, Charleston

Communications—A. B. Credle, Clemson

Further organization of technical committees was postponed to a program meeting, planned for the last week in April.

The meeting had an attendance of about 30 Institute members and interested nonmembers. F. R. Maxwell, Jr., professor of electrical engineering of the University of Alabama and Institute vice-president for the Southern District, was present at the meeting and helped the Section with organization details.

The following general committees have been appointed by the chairman:

Program committee: N. H. Coit, Columbia, chairman; F. T. Tingley, Clemson; J. E. Sirrine, Greenville

Membership committee: H. M. Stokely, Greenville, chairman; H. L. Stokes, Walterboro; C. O. Warren, Columbia

Bylaws committee: F. W. Chapman, Greenwood, chairman; G. R. Barksdale, Greenwood; O. L. Smith, Charleston

Informal Luncheons. Since March 1939 the Philadelphia Section has held informal weekly luncheons, which have become very popular. The largest attendance for a luncheon was 52, the average 22 members. Members attend as often as they wish. There are no speeches, schedule, toastmaster, or special menu. A special notice

Future AIEE Meetings

Summer Convention
Swampscott, Mass., June 24–28, 1940

Pacific Coast Convention
Los Angeles, Calif., August 26–30, 1940

Middle Eastern District Meeting
Cincinnati, Ohio, October 9–11, 1940

Winter Convention
Philadelphia, Pa., January 27–31, 1941

of the luncheons is sent out occasionally, and a brief announcement carried on the regular meeting notices. The luncheons are held at the Engineers Club, which is near the principal office buildings. A drawing is held each week for a complimentary luncheon. Since the luncheons were started, the American Society of Civil Engineers and The American Society of Mechanical Engineers have instituted similar luncheons for their members.

Communications Program Popular. Nearly 300 members and guests attended the February meeting of the Kansas City Section, the largest attendance of the current season and one of the largest ever secured at a technical session. More than 100 attended the dinner before the meeting. A. F. Rose, toll plant extension engineer, American Telephone and Telegraph Company, gave an illustrated lecture on multichannel carrier telephony, including demonstration of some characteristics of the feedback amplifier. A motion picture, "Dancing Telephone Cables," showing some extreme vertical vibrations in cables covered with ice, was presented by J. H. Schweitzer, Southwestern Bell Telephone Company, who discussed the methods employed in combating this action.

Discuss Registration Laws. To provide an opportunity for a full discussion of possible legislation on the registration of engineers, the Pittsfield Section held a meeting on January 30, to which all electrical, mechanical, civil, chemical, and other interested engineers in western Massachusetts were invited. The discussion was led by C. R. Beardsley, chairman of the Institute's committee on legislation affecting the engineering profession.

Other Clubs Entertained. Members of the Rotary and Kiwanis clubs attended a "Good Fellowship" meeting of the Lehigh Valley Section, at Bloomsburg, Pa., January 12, 1940. Features of the meeting were a turkey dinner, a talk on the mining, manufacture, and insulation of copper wire, a talk on the sterilization of milk by electricity, "good" singing by the Kiwanis Octette, and "loud" singing by all present. A total of 135 attended, 48 members and 87 guests.

Past Chairmen Honored. Following an annual custom of many years' standing, the Los Angeles Section celebrated "past chairman's night" at its regular February meeting All past chairmen are invited to attend the dinner meeting as guests of the Section, one is appointed toastmaster, and each is introduced and given an opportunity to speak. Of 25 living past chairmen, 21 attended this year.

Bowling Tournament. About 60 members of the Boston Section took part last season in a bowling tournament sponsored by the Section. Alleys were reserved for an hour and a half preceding Section meetings, and an average of 20 members participated at each meeting. Small prizes for high total, high single string, and low man were distributed each time, and several grand prizes set aside for the season's winners, from among prizes donated by local electrical companies to be drawn at the annual dinner meeting at the close of the season. The cost of the bowling contests averaged between $4.00 and $4.50 per meeting, and the activity is regarded by the Section as having done more than any other in recent years to increase fellowship among the members.

Branch • • • •

Branch Greeted Over Television

Members of the Pratt Institute Student Branch received personal greetings over television from David Sarnoff (M'23) president, Radio Corporation of America, and an alumnus of Pratt Institute, James G. Harbord, chairman of the board of directors of Pratt, and John Hayes Hammond and Gano Dunn (A'91, F'12) members of the board, in a special broadcast to the Branch meeting February 1, 1940.

The Pratt Branch, membership of which represents 82 per cent of eligible students, publishes a monthly bulletin announcing its activities. It also has issued an "employment bulletin" containing photographs and records of the graduating class for the information of prospective employers.

Inter-Branch Get-Together. To encourage acquaintance and correlation of activities among the Branches of the New York metropolitan area, the College of the City of New York Branch held a smoker February 23, 1940. The gathering, the first of its kind in the area, was regarded as highly successful. Attendance from the various Branches invited was: CCNY, 68; Pratt Institute, 17; Columbia University, 7; Brooklyn Polytechnic Institute, 7; Cooper Union, 6; Rutgers University, 2; New York University, 1; Newark College, 0. Novel announcements in the form of blueprints were issued by the CCNY Branch.

Standards • • •

Subcommittee to Standardize Wet Testing

For a number of years there has been dissatisfaction in the industry in regard to wet testing of equipment because such standards as existed have not been conducive to consistent and comparative measurements. At one of the early meetings of the laboratory subcommittee of the joint committee on insulation co-ordination, the suggestion was adopted:

"that a common mode of procedure for the making of wet flashover tests be outlined to insure that the data obtained may be as nearly as possible on the same basis."

The laboratory subcommittee thereupon investigated the matter of laboratory procedure, such as the effect on the test results of different-shaped nozzles and water pressure, methods of measuring precipitation, correction factors for water resistance and for precipitation. As a result of their investigation over a number of years, they made certain recommendations which were included in a report presented at the 1940 winter convention of the Institute.

The laboratory subcommittee can, of course, only make recommendations and it is desirable that its work be carried forward to the point where a standard of wet testing can be included in the revision of test standards for those devices, such as insulators and bushings, that require wet testing. With this in view the AIEE standards committee, through its co-ordinating committee 3, has set up a subcommittee under the chairmanship of R. T. Henry to standardize the whole procedure of wet testing. The subcommittee hopes to arrive at a single rate of precipitation and a single value of the resistivity of water on which to base the results of wet tests on various kinds of apparatus, and thus facilitate apparatus testing.

Revision of AIEE Standard No. 1 Nearing Completion

The AIEE standards committee through its co-ordinating committee 4 has been engaged for some time in a revision of the pamphlet entitled "General Principles Upon Which Temperature Limits Are Based in the Rating of Electrical Machinery and Apparatus", number one in the standards series.

Important recent trends to which consideration has been given in preparing these revised principles include:

1. The much greater use of enclosed or protected types of electric motors, making a change from the thermometer to the resistance method of temperature measurement logical.

2. The development of new insulating materials and methods of treatment, whose space-saving and heat-resisting qualities place greater emphasis on temperature limitations.

3. The opening up of new fields of application, such as aviation equipment and air conditioning, increasing the varieties of special purpose apparatus to be supplied by the electrical industry.

In preparing new or improved standards to cover the needs of the electrical industry, both theoretical and practical knowledge should be used to the fullest extent. Individual standards for specific types of apparatus should be correlated with each other to establish reasonable "temperature-rise levels" for electrical systems, thus improving momentary overload performance and promoting consistency in safety provisions. At the same time, it is important that individual types of apparatus and specific purpose applications should be free to use different temperature-rise values in accordance with their individual economic problems.

This revision of the original AIEE Standard No. 1 has been prepared in the hope that it will be useful in the continuing development of such a free but co-ordinated system of electrical standards.

The revised report was discussed at the March 26 meeting of the standards committee.

Personal . . .

AIEE Members Among Those Honored as "Modern Pioneers"

Awards were presented during February to 572 American scientists and inventors selected as "Modern Pioneers" in the National Association of Manufacturers' program celebrating the 150th anniversary of the American patent system (*EE, Dec. '39, p. 529*). Especially honored as national "Modern Pioneers" were 18 individuals and the group of 11 scientists responsible for the development of the new artificial fiber "Nylon". Among those honored for their contributions to the American standard of living during the last 25 years were the following members of the Institute:

National awards—**W. D. Coolidge** (A'10, M'34, Edison medalist) director, research laboratory, General Electric Company, Schenectady, N. Y.; **Lee de Forest** (A'04, F'18), Lee de Forest Laboratories, Los Angeles, Calif.; **C. F. Kettering** (A'04, F'14) vice-president in charge of research, General Motors Corporation, Dayton, Ohio; **V. K. Zworykin** (M'22) director, electronics research laboratory, RCA Manufacturing Company, Camden, N. J.

New York area—**H. A. Affel** (A'18, M'23) assistant director of transmission development, Bell Telephone Laboratories, Inc., New York, N. Y.; **H. S. Black** (A'23, M'33) technical staff, Bell Telephone Laboratories, Inc., New York; **J. R. Carson** (A'19, F'33) research mathematician, Bell Telephone Laboratories, Inc., New York; **Gano Dunn** (A'91, F'12, Edison medalist) president, J. G. White Engineering Corporation, New York; **G. W. Elmen** (M'21, F'27) research physicist, Bell Telephone Laboratories, Inc., New York; **H. C. Ford** (A'05) president, Ford Instrument Company, Long Island City, N. Y.; **A. N. Goldsmith** (M'15, F'20) consulting engineer, New York; **W. N. Goodwin, Jr.** (A'06, F'13) chief engineer and director of research, Weston Electrical Instrument Corporation, Newark, N. J.; **L. A. Hazeltine** (F'35) professor of physical mathematics, Stevens Institute of Technology, Hoboken, N. J.; **R. A. Heising** (A'15, F'39) radio research engineer, Bell Telephone Laboratories, Inc., New York; **C. J. Holslag** (M'19) president, Electric Arc Cutting and Welding Company, Newark; **D. S. Jacobus** (A'03) advisory engineer, The Babcock and Wilcox Company, New York; **B. W. Kendall** (M'18, F'29) toll development director, Bell Telephone Laboratories, Inc., New York; **Albert Kingsbury** (A'08) president, Kingsbury Machine Works, Inc., Philadelphia, Pa.; **R. H. Ranger** (M'22) president, Rangerstone, Inc., Newark; **H. E. Shreeve** (A'06, F'30) retired, American Telephone and Telegraph Company, New York; **W. R. Whitney** (A'01, Edison medalist) vice-president in charge of research, General Electric Company, Schenectady, N. Y. *Joint awards:* **T. M. Shrader** (M'30) in charge of radio tube advance development, RCA Radiotron division, RCA Manufacturing Company, Harrison, N. J.; **H. H. Beverage** (A'23, M'34) chief research engineer, RCA Communications, Inc., Riverhead, N. Y.; **C. W. Hansell** (A'23) transmitter research engineer, RCA Communications, Inc., Rocky Point, N. Y.; **G. L. Usselman** (A'24) radio engineer, RCA Communications, Inc., Rocky Point.

Baltimore area—**A. L. Penniman** (A'15, M'32) general superintendent, electric operations, Consolidated Gas, Electric Light, and Power Company, Baltimore, Md.; **F. E. Ricketts** (A'16), superintendent, electric stations, Consolidated Gas, Electric Light, and Power Company, Baltimore. *Joint award:* **P. L. Betz** (A'27) research physicist, Consolidated Gas, Electric Light, and Power Company, Baltimore.

Boston area—**H. E. Edgerton** (A'27, M'32) assistant professor of electrical engineering, Massachusetts Institute of Technology, Cambridge, Mass.; **H. E. Warren** (A'02, Lamme medalist) president, Warren Telechron Company, Ashland, Mass.

Chicago area—**W. A. Darrah** (A'09) president, Continental Industrial Engineers, Inc., Chicago, Ill.; **R. H. George** (A'24) assistant professor, electrical engineering division, engineering experiment station, Purdue University, Lafayette, Ind.; **G. A. Hughes** (A'17) president, Edison General Electric Appliance Company, Inc., Chicago; **H. L. Krum** (A'12, F'27) vice-president, Teletype Corporation, Chicago; **C. E. Lomax** (M'34) supervisor, automatic telephone system development, Associated Electric Laboratories, Inc., Chicago; **M. L. Nelson** (M'34) development engineer, Associated Electric Laboratories, Inc., Chicago; **W. M. White** (M'21) manager and chief engineer, hydraulic department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis.; **John Wicks** (A'06) development engineer, Automatic Electric Company, Chicago.

Cleveland area—**Frank Conrad** (A'02, F'37, Edison medalist, Lamme medalist) assistant chief engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.; **L. O. Grondahl** (A'26) director of research and engineering, Union Switch and Signal Company, Swissvale, Pa.; **J. K. Hodnette** (A'28, M'30) division engineer, distribution division, Westinghouse Electric and Manufacturing Company, Sharon, Pa.; **J. F. Lincoln** (A'08, F'39) president, Lincoln Electric Company, Cleveland, Ohio; **J. C. Lincoln** (A'07, F'32) chairman of the board of directors, Lincoln Electric Company, Cleveland.

Detroit area—**B. F. Bailey** (A'07, F'21) head of the department of electrical engineering, University of Michigan, Ann Arbor, Mich.

Hartford area—**H. J. Blakeslee** (A'02, M'15) president, The States Company, Hartford, Conn.

Los Angeles area—**Frederick Bedell** (A'91, F'26) R. C. Burt Scientific Laboratories, Pasadena, Calif.; **L. F. Hunt** (A'21, F'38) protection engineer, Southern California Edison Company, Ltd., Los Angeles, Calif. *Joint award:* **W. A. Schmidt** (M'22) president and general manager, Western Precipitation Company, Los Angeles.

Philadelphia area—**P. H. Chase** (A'12, M'18) chief engineer, Philadelphia Electric Company, Philadelphia, Pa.; **Francis Hodgkinson** (A'02) consulting mechanical engineer, New York, N. Y. (retired, Westinghouse Electric and Manufacturing Company, Philadelphia); **M. E. Leeds** (A'01, F'26) chairman of the board of directors, Leeds and Northrup Company, Philadelphia; **E. F. Northrup** (A'01, F'13) vice-president and technical adviser, Ajax Electrothermic Corporation, Trenton, N. J.; **D. C. Prince** (A'16, F'26) chief engineer, Philadelphia works, General Electric Company, Philadelphia.

Rochester area—**J. H. Levis** (A'21) circuit designer, Stromberg-Carlson Telephone Manufacturing Company, Rochester, N. Y.

San Francisco area—**H. E. Kennedy** (A'34) Berkeley, Calif.

St. Louis area—**F. B. Adam** (A'04) president, Frank Adam Electric Company, St. Louis, Mo.; **E. S. Pillsbury** (M'19) president and managing director, Century Electric Company, St. Louis.

E. G. Fox (A'12, M'20) vice-president, Freyn Engineering Company, Chicago, Ill., has been nominated as president of the Western Society of Engineers, for 1940–41. Born January 1, 1887, in Milwaukee, Wis., he received the degree of bachelor of science in electrical engineering from the University of Wisconsin in 1908. During the following year he was employed by the Northern Electric Manufacturing Company, Madison, Wis., and from 1909 to 1914 at the Fort Wayne (Ind.) works of the General Electric Company. He was an electrical engineer for the Mark Engineering Company, Evanston, Ill., 1914–16, and for the Steel and Tube Company of America, Indiana Harbor, Ind., 1916–20. He joined Freyn, Brassert and Company (later Freyn Engineering Company) consulting engineers, Chicago, in 1920. From 1928 to 1933 he spent much time in Leningrad, USSR, in connection with the development of the iron and steel industry. He was made a vice-president of the company in 1934. He is also a member of the Association of Iron and Steel Engineers and is the author of books and technical papers. He is at present second vice-president of the Western Society of Engineers.

F. H. Lane (M'23, F'37) manager, engineering division, Public Utility Engineering and Service Corporation, Chicago, Ill., has been nominated first vice-president of the Western Society of Engineers for 1940–41. Born June 7, 1882, at St. Louis, Mo., he received the degree of mechanical engineer from Lewis Institute in 1904. Following graduation he was employed as a draftsman by H. M. Byllesby and Company, Chicago, predecessor to the Byllesby Engineering and Management Corporation, which was later succeeded by Public Utility Engineering and Service Corporation. He was engaged in preliminary investigations of projects, 1906–08; was assistant superintendent of construction at Galena, Ill., 1909–10; and carried on general investigations and appraisals of public-utility properties, 1910–17, being placed in charge of the work in 1915. In 1917 he was made manager of engineering and construction, and with the formation of the present company, assumed the position of manager of the engineering division. He is a director of the AIEE, a member of The American Society of Mechanical Engineers, and at present is third vice-president of the Western Society of Engineers.

O. B. Coldwell (A'03, F'12) has retired as vice-president of the Portland General Electric Company, Portland, Ore., but will

continue with the company as consulting engineer. He was born November 28, 1875, at Salem, Ore., and studied electrical engineering at Stanford University and Cornell University, graduating from Cornell in 1902, with the degree of electrical engineer. During vacations and from 1893 to 1897 he worked in various capacities for the Willamette Falls Electric Company, Portland, and its successor, the Portland General Electric Company, and following graduation was employed by the latter as assistant superintendent. He became successively superintendent of the light and power department, general superintendent, vice-president in charge of transportation, and vice-president in charge of hydroelectric development and general construction. He has been a vice-president for 24 years, and in his association with the company and its affiliates has been active in most departments. He is a past president of the Northwest Electric Light and Power Association and has been active in committee work for the Edison Electric Institute and its predecessor the National Electric Light Association. He is also a member of Sigma Xi.

C. H. Sharp (A'02, F'12) president of the United States Committee of the International Electrotechnical Commission, has been elected honorary president of the Committee, succeeding the late Doctor A. E. Kennelly (A'88, F'13, HM'33). Born at Seneca Falls, N. Y., December 5, 1869, he received the degrees of bachelor of arts, Hamilton College, 1890, and doctor of philosophy, Cornell University, 1895, and also studied at the University of Leipzig, Germany. He was an assistant and instructor in physics at Cornell, Ithaca, N. Y., 1895 to 1901. He became test officer of the Electrical Testing Laboratories, New York, N. Y., in 1901, and vice-president and technical adviser in 1914, continuing to hold those positions until his retirement in 1933. He is the inventor of many instruments and author of many papers. He has served the USNC as delegate at 11 international conventions of the IEC, the first being at Turin, Italy, in 1911; as secretary 1921–23; and as president since 1924. He has also served as president of the United States National Committee of the International Commission on Illumination (1914–28), and is a past president of the Illuminating Engineering Society, and also a member of the American Physical Society, American Association for the Advancement of Science, Optical Society of America, and Société Française des Électriciens.

C. A. Robinson (A'11, F'22) formerly general manager, Chesapeake and Potomac Telephone Company, Washington, D. C., has been appointed vice-president and general manager. He was born September 26, 1881, in Anne Arundel County, Md., and received the degrees of bachelor of arts from Johns Hopkins University in 1903 and mechanical engineer from Cornell University in 1906. He was in the test department of General Electric Company, Schenectady, N. Y., 1903–04, and in 1906 entered the engineering department of the New York and New Jersey Telephone Company. He was transferred to the engineering department of the American Telephone and Telegraph Company in 1909, to handle transmission problems. In 1919 he was sent to Europe on a toll telephone cable project by Western Electric Company, and on his return was appointed transmission engineer, American Telephone and Telegraph Company. In 1920 he was made chief engineer of the Chesapeake and Potomac telephone companies, in 1929 assistant vice-president, and in 1931 general manager of the Chesapeake and Potomac Telephone Company of West Virginia. He was made general manager of the Washington company in 1936.

E. A. Graham (A'10, F'20) has been made manager of the engineering and research division of the United States Testing Company, Inc., with headquarters at New York, N. Y. The division has been created by the merger of the laboratory facilities of the company with the E. E. Free Laboratories, with which Mr. Graham has been associated for the past year. Born September 8, 1885, at Kelly, N. Mex., he received the degree of bachelor of science in mechanical engineering from New Mexico State College in 1906. From 1906 to 1914 he was engaged in electrical engineering for Westinghouse Electric and Manufacturing Company, Canadian Westinghouse Company, and Winnipeg (Can.) Electric Company. He became associated with Electric Bond and Share Company in 1914, working on engineering and economic investigations and as manager of properties in Latin American countries, until 1925. He was later national service manager and export manager for the Servel Corporation, and manager of sales in Cuba for the Detroit Graphite Corporation. From 1933 to 1938 he was on the staff of Sanderson and Porter, New York, N. Y., on industrial engineering work, before going to the E. E. Free Laboratories.

David Levinger (M'30) has been apppinted works manager, Western Electric Company, Inc., Hawthorne Station, Chicago, Ill. Born August 27, 1887, at Delta, Idaho, he was educated at Chicago Technical College. He was a steel inspector for International Harvester Company, Chicago, Ill., 1907–10. He has been with Western Electric since 1910, as mechanical engineer (1910–18), engineer of mechanical methods (1918–20), assistant technical superintendent (1920–22), assistant superintendent of development (1922–25), superintendent of manufacturing development (1925–28), and engineer of manufacture (1928–39). During the past year he has been assistant to the vice-president and works manager. He is also a member of the American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, and American Association for the Advancement of Science.

W. G. B. Euler (A'08, M'33) has been appointed chief engineer of Pacific Gas and Electric Company, San Francisco, Calif. He was born in San Francisco, September 24, 1883, and received the degree of bachelor of science from the University of California in 1905. From 1905 to 1910 he was employed by General Electric Company on construction and engineering work on the Pacific Coast. In 1910 he was employed by the Great Western Power Company, San Francisco, as division superintendent, later becoming superintendent of operation (1919) and general superintendent in charge of operations (1929). When the company merged with Pacific Gas and Electric he was made general superintendent of the San Francisco and East Bay divisions, and will continue to act in that capacity in addition to his duties as chief engineer.

A. F. Dixon (A'14, F'26) formerly director of systems development, Bell Telephone Laboratories, Inc., New York, N. Y., has been made an assistant vice-president. As of April 30, 1940, he is retiring at his own request. He was born at Victoria, Ill., December 5, 1877, and studied at Armour Institute. He was employed by the B. F. Goodrich Company, Akron, Ohio, and the Stirling Company, Barberton, Ohio, before becoming a draftsman for Western Electric Company, Chicago, Ill., in 1902. In 1905 he was transferred to the development engineering department at Chicago, and in 1907 transferred to New York. He was placed in charge of printing telegraph organization in 1911, and of the development of machine switching systems in 1916. In 1919 he was placed in charge of all telephone systems development in the laboratories of Western Electric, and continued with that work after the establishment of Bell Telephone Laboratories. He holds many patents for telephone and telegraph apparatus.

William Wilson (M'23) formerly assistant vice-president, Bell Telephone Laboratories, Inc., New York, N. Y., is now chairman of the consulting staff, and also assistant vice-president in charge of labor relations, as part of a general rearrangement of the personnel organization of the Laboratories. Other changes in position or title include: **Lloyd Espenschied** (A'18, F'30) formerly research consultant, now consulting engineer; **C. W. Green** (A'10, F'40) formerly carrier telephone engineer, now consulting engineer; **Harry Nyquist** (M'24) formerly telephone engineer, American Telephone and Telegraph Company, now consulting engineer at Bell Laboratories. Among positions, reporting to director of apparatus development, changes include: **William Fondiller** (M'15, F'26) formerly electrical apparatus director, now assistant director of apparatus development; **H. A. Frederick** (A'12, F'28) formerly electromechanical apparatus director, now director of switching apparatus development; **R. A. Haislip** (A'21, M'21) formerly outside plant development engineer, now director of outside plant development; **W. H. Martin** (A'14, F'30) formerly switching research director, now director of station apparatus development; **G. D. Edwards** (A'16, M'26) formerly inspection engineer, now director of quality assurance. Reporting to director of research, changes include: **B. W. Kendall** (M'18, F'29) formerly toll development director, now director of circuit research; **Ralph Bown** (M'30) formerly radio research director, now director of radio and television research. **A. B. Clark** (M'19, F'30) formerly director of transmission development, is now director of sys-

tems development, heading both the transmission development and systems development departments, which have been merged. He succeeds **A. F. Dixon** (A'14, F'26) now assistant vice-president. Other changes in that department include: **H. M. Bascom** (M'19, F'30) formerly local facilities director, now director of switching engineering; **R. G. McCurdy** (A'16, F'34) assistant director of transmission development, now director of transmission engineering; **D. A. Quarles** (A'23, M'29) formerly outside plant development director, now director of transmission development; and **Morton Sultzer** (A'13, M'34) formerly protection development service engineer, now executive assistant.

R. W. Beck (M'37) formerly an electrical engineer for the Bonneville power project, has been named manager of the Gray's Harbor, Wash., Public Utility District. He was consulting engineer for the District during the survey of the holdings of the Gray's Harbor Railway and Light Company. A native (1896) of Chicago, Ill., Mr. Beck attended Oregon State College, and was employed by the Montana Power Company and the California Oregon Power Company before becoming an engineer for the City of Seattle (Wash.) Department of Lighting in 1925. He was made an utility engineer for the Department in 1936, and was also consultant for various public power projects in the state of Washington. In 1937 he was engaged to make valuation studies of privately owned utilities in Nebraska for the several public power districts of the state. He was later an electrical engineer on the Bonneville project, Portland, Ore., and was recently appointed consulting engineer by the Klickitat County (Wash.) Public Utility District.

W. W. Truran (A'23, M'30) formerly general toll engineer, New York (N. Y.) Telephone Company, has been appointed chief engineer of the Long Island area. He was born May 25, 1894, at Milbank, S. Dak., and received the degree of bachelor of science in electrical engineering from the University of Wisconsin in 1917. He was employed by the New York Telephone Company as engineering assistant in the same year, and was appointed assistant engineer in 1921. In 1925 he was made engineer in charge of toll fundamental plans, and in 1928, general toll engineer. **A. A. Williamson** (M'22) formerly engineer of transmission and protection, Long Island area, has been appointed general toll engineer, New York Telephone Company. He was first employed by the Bell system in 1909, following graduation from Stevens Institute with the degree of mechanical engineer.

J. R. Kearney (M'25) president and founder of the Kearney Corporation, manufacturers of utility equipment, St. Louis, Mo., has become chairman of the board of the company. Born in Louisville, Ky., July 2, 1878, he began work in 1893 on construction and engineering jobs. Employed by the W. N. Matthews Corporation, St. Louis, as sales engineer in 1906, he continued with the company 20 years, becoming district sales engineer, and later director of electrical sales. He organized his own company in 1926 and has served as president ever since. **W. A. Heinrich** (A'19, M'35) has been made executive vice-president and director of engineering of the Kearney Corporation. A native (1896) of St. Louis, he was associated with the W. N. Matthews Corporation from 1913 to 1926. He was one of the organizers of the Kearney Corporation, becoming its chief engineer. He has been a vice-president since 1930.

J. T. Littleton (A'23, F'28) who has been chief of the physical laboratory, Corning Glass Works, Corning, N. Y., since 1917, has been appointed to the newly created position of assistant director of research. Born at Bellehaven, Va., July 7, 1887, he received the degrees of bachelor of arts, Southern University, 1906; master of arts, Tulane University, 1908; and doctor of philosophy, University of Wisconsin, 1911. He was a teaching assistant at Wisconsin 1909–11, and instructor in physics at the University of Michigan, Ann Arbor, 1911–13. He became associated with the Corning laboratory as a physicist in 1913 and was made chief four years later. He is also a member of the American Ceramics Society, American Physical Society, American Association for the Advancement of Science, American Optical Society, and American Society for Testing Materials.

R. H. Van Horn (A'22, M'36) formerly chief engineer, United Illuminating Company, New Haven, Conn., has been appointed a vice-president of the company. He was born March 9, 1893, at Lambertville, N. J., and received the degree of bachelor of electrical science from Brown University in 1917. He entered the student course of General Electric Company, Schenectady, N. Y., in the same year, returning in 1919 after two years' service in the United States Army. In 1920 he became an engineer for General Electric and continued with the company until 1928, when he joined the United Illuminating Company as an engineer. He was made manager of the Bridgeport division of the latter company in 1930, and later became chief engineer.

E. F. Nuezel (A'27, M'39) superintendent, underground electric transmission and distribution department, Cincinnati (Ohio) Gas and Electric Company, has been elected president of the Technical and Scientific Societies Council of Cincinnati. He served as vice-president of the Council last year.

R. W. Eaton (A'07, M'13) formerly public service and traffic engineer for the City of Providence, R. I., has been assigned full-time duties as traffic engineer, concentrating upon problems of highway safety and related topics.

F. J. Leerburger (A'28, M'35) recently appointed principal valuation engineer for the New York State Public Service Commission, has opened his own office in New York, N. Y., as a practicing consulting engineer.

H. P. Liversidge (A'12, M'17) president, Philadelphia Electric Company, Philadelphia, Pa., has recently been elected a member of the board of managers of the Franklin Institute.

H. L. Miller (A'38) president, Utilities Engineering Company, Philadelphia, Pa., has been elected vice-president of the Electrical Association of Philadelphia for 1940.

R. K. Lane (M'37) vice-president, Public Service Company of Oklahoma, Tulsa, has been elected a vice-president of the Oklahoma Utilities Association for 1940.

Obituary • • •

James Ewart Taggart (M'37) executive engineer, electricity branch, Punjab Public Works Department, Lahore, India, died some time ago, according to information just received at Institute headquarters. He was born at Castletown, Isle of Man, British Isles, April 23, 1896, and graduated from Faraday House Electrical Engineering College, London, England, in 1922. He became a student apprentice with the English Electric Company, Ltd., Preston, in 1921, assistant production and test engineer, 1922, and assistant to the general works manager at the company's main office in London in 1923. In 1926 he became assistant transmission and distribution engineer for the Burmah Oil Company, Ltd., continuing with the company until 1928. From 1928 to 1931 he was transmission-line engineer and later district engineer for the Perak River Hydro-Electric Power Company, Ltd., Malaya. Returning to England in 1931 he was construction engineer for the J. L. Eve Construction Company, Ltd., London, and for the North Eastern Electric Supply Company, Ltd., Newcastle-on-Tyne. He had been with the Punjab Public Works Department since 1934. He was also a member of The Institution of Electrical Engineers of Great Britain.

Carl Dunham Knight (A'05, M'13) professor of experimental electrical engineering, Worcester Polytechnic Institute, Worcester, Mass., died February 28, 1940. He was born at Putney, Vermont, October 14, 1880, and received the degrees of bachelor of science in 1903 and electrical engineer in 1908 from Worcester Polytechnic Institute. He spent the following year in the testing department of General Electric Company, Schenectady, N. Y., and in 1904 became an instructur in electrical engineering at Worcester Polytechnic. He became assistant professor of experimental electrical engineering in 1908, and full professor in 1920. Since 1906 he had held the position of superintendent of electrical maintenance for the institution, duties of which included designing light and power installation for new construction. He was Student Branch counselor at Worcester Polytechnic 1931–38, and was also a member of the Society for the Promotion of Engineering

Education, Illuminating Engineering Society, Tau Beta Pi, and Sigma Xi.

George Sanford Davis (A'04, M'12) assistant electrical engineer, Department of National Defense, Ottawa, Ont., Can., died December 29, 1939. He was born November 28, 1874, at Cincinnati, Ohio, and educated there. He was employed by Cincinnati utility companies, 1893–95, and later engaged in electrical contracting work for himself and for others. He was employed by the Niagara Falls Hydro Power and Manufacturing Company, Niagara Falls, N. Y., 1897–99, and in 1900 went with the Shawinigan Water and Power Company, Shawinigan Falls, Que., Can. In 1905 he joined the Canadian General Electric Company as construction superintendent. He was later district engineer in Ottawa and in Montreal. He entered consulting practice in 1920. Since 1937 he had been with the Department of National Defence in Ottawa. He was also a member of the Engineering Institute of Canada.

Irwin B. Hopkins (A'37) electrical draftsman, City Transit Department, City of Philadelphia, Pa., died January 12, 1940. He was born at Brooklyn, N. Y., November 8, 1894, and graduated in industrial electrical engineering from Pratt Institute. He was employed as an electrical draftsman by Krantz Manufacturing Company, Brooklyn, 1917–19, and by the Brooklyn Edison Company, 1919–20. From 1920 to 1924 he was an insurance surveyor and inspector for the Sanborn Map Company, Pelham, N. Y. He was employed by the Philadelphia Electric Company, Philadelphia, Pa., on substation design from 1924 to 1931, later becoming an electrical designer for the United States Navy at the Philadelphia Navy Yard. He had been with the City Transit Department since 1936.

Membership

Recommended for Transfer

The board of examiners, at its meeting on March 14, 1940, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the national secretary.

To Grade of Member

Anfang, E. L., coil designer, Allis-Chalmers Manufacturing Company, Milwaukee, Wis.
de la Rosa, J. C., electrical superintendent, Toronto Transportation Commission, Toronto, Ont., Can.
Hentzen, H. K., exchange plant engineer, Southwestern Bell Telephone Company, Wichita, Kans.
Hollister, J. W. A., assistant electrical engineer, The Howard P. Foley Company, Inc., Washington, D. C.
Joseph, J. S., equipment engineer, Southwestern Bell Telephone Company, Oklahoma City, Okla.
King, F. H., superintendent, electric light department, Burlington, Vt.
Koopman, R. J. W., assistant professor of electrical engineering, University of Kansas, Lawrence.
Ochsner, W. W., electrical engineer, Southwestern Light and Power Company, Lawton, Okla.
Palmer, S. G., professor of electrical engineering, University of Nevada, Reno.
Scheer, G. B., consulting engineer, San Francisco, Calif.
Shelley, P., assistant electrical engineer, Oklahoma Gas and Electric Company, Oklahoma City.
Vivian, J. H., protection engineer, Southern California Edison Company, Ltd., Los Angeles, Calif.

12 to Grade of Member.

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Names of applicants in the United States and Canada are arranged by geographical Districts. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the national secretary before April 30, 1940 or June 30, 1940, if the applicant resides outside of the United States or Canada.

United States and Canada

1. North Eastern

Abell, E. D., General Electric Company, Lynn, Mass.
Acord, T. E., General Electric Company, Schenectady, N. Y.
Alla, F. V., Hygrade Sylvania Corporation, Salem, Mass.
Anderson, C. H., New York Telephone Company, Albany, N. Y.
Anderson, D. P., General Electric Company, Pittsfield, Mass.
Andrews, G. E., Jr., Narragansett Electric Company, Providence, R. I.
Baker, J. M., General Electric Company, Lynn, Mass.
Baldwin, P. B., General Electric Company, Schenectady, N. Y.
Beardslee, R. F., Connecticut Light and Power Company, Waterbury.
Bell, N. R., General Electric Company, Lynn, Mass.
Blake, A. E., Jr., General Electric Company, Lynn, Mass.
Burley, C. F., Machlett Laboratories, Inc., Springdale, Conn.
Butler, J. B., Hamilton Standard Propellers, East Hartford, Conn.
Camp, R. C., General Electric Company, Schenectady, N. Y.
Carr, M. K., Spencer Lens Company, Buffalo, N. Y.
Clift, C. W., 210 Pleasant Street, Whitman, Mass.
Congdon, M. H., Electric Specialty Company, Stamford, Conn.
Copp, J. H., General Electric Company, Schenectady, N. Y.
Dianosich, C. S., Hanna Furnace Corporation, Lackawanna, N. Y.
Diehm, W. A., General Electric Company, Schenectady, N. Y.
Dodd, M. D., General Electric Company, Pittsfield, Mass.
Doran, R. J., Central New York Power Corporation, Watertown, N. Y.
Durgin, H. L. (Member), Central Vermont Public Service Corporation, Rutland, Vt.
Faulkingham, L. H., New Hampshire Gas and Electric Company, Portsmouth, N. H.
Glick, S. G., General Electric Company, Schenectady, N. Y.
Goldstein, G. D., 407 Oxford Street, Rochester, N. Y.
Hambrick, R. D., General Electric Company, Schenectady, N. Y.
Hilden, W. C., General Electric Company, Schenectady, N. Y.
Humphrey, C. D., Western Massachusetts Companies, Springfield, Mass.
Hyland, J. L. (Member), Turners Falls Power and Electric Company, Turners Falls, Mass.
Jamieson, G. E., General Electric Company, Schenectady, N. Y.
Johnson, I. B., General Electric Company, Schenectady, N. Y.
Kimball, R. E., General Electric Company, Schenectady, N. Y.
Kitzmiller, M. W., General Electric Company, Schenectady, N. Y.
Lasher, C. C., General Electric Company, Schenectady, N. Y.
Little, G., Jr., General Electric Company, Schenectady, N. Y.
Morris, J. P., General Electric Company, West Lynn, Mass.
Muir, W. A., General Electric Company, Schenectady, N. Y.
Nichols, A. J., Buffalo Niagara Electric Corporation, Buffalo, N. Y.
Recka, F. A., 254 Linden Street, Waltham, Mass.
Reimann, A. G., 1968 Parker Street, Schenectady, N. Y.
Rosenblatt, J., New York State Department of Labor, Albany.
Schultz, N. R., General Electric Company, Schenectady, N. Y.
Schwennesen, A. B. (Member), New York State Electric and Gas Corporation, Elmira.
Shaw, M. R., Jr., Corning Glass Works, Corning, N. Y.
Shelton, E. E., General Electric Company, Pittsfield, Mass.
Shipp, E. C., General Electric Company, Schenectady, N. Y.
Silliman, M. A., Central New York Power Corporation, Utica, N. Y.
Springer, R. W., Narragansett Electric Company, Providence, R. I.
Tapscott, R. L., General Electric Company, Schenectady, N. Y.
Webb, D. R., General Electric Company, Schenectady, N. Y.
Worthen, C. E., General Radio Company, Cambridge, Mass.
Zelaites, C. A., Narragansett Electric Company, Providence, R. I.

2. Middle Eastern

Allen, E. H., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Baker, V. B., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Bliss, M., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Bohn, C. R., Ohio Power Company, Lima.
Bradley, J. K., Westinghouse Electric and Manufacturing Company, Wilkinsburg, Pa.
Brenner, C. H., De Laval Steam Turbine Company, Trenton, N. J.
Brunner, G. J., Cincinnati Gas and Electric Company, Cincinnati, Ohio.
Budny, C. T., United States Navy, Philadelphia, Pa.
Burch, K. E., New Jersey State Highway Department, Trenton.
Calhoun, J. F., Philadelphia Electric Company, Philadelphia, Pa.
Caldwell, D. W., General Electric Company, Cleveland, Ohio.
Campbell, B., Procter and Gamble Company, Ivorydale, Ohio.
Campbell, J., Jr., Bell Telephone Company of Pennsylvania, Philadelphia.
Carl, E. W., Glenn L. Martin Company, Baltimore, Md.
Carpenter, J. W., Rural Electrification Administration, Washington, D. C.
Castonguay, W. R., District of Columbia Highway Department, Washington, D. C.
Charny, A. L. (Member), Bell Telephone Company of Pennsylvania, Philadelphia.
Chase, P. W., Jr., The J. S. Johnson Company, Baltimore, Md.
Chester, P. F., F. R. Hannon Electric Company, Canton, Ohio.
Chyba, H. J., Consolidated Gas, Electric Light and Power Company of Baltimore, Baltimore, Md.
Clautice, E. W., Calvert Distilling Company, Relay, Md.
Davis, L. J., North Electric Manufacturing Company, Galion, Ohio.
DeFuria, P. B., Island Creek Coal Company, Holden, W. Va.
Dennis, F. F., Pennsylvania State College, State College.
Detwiler, J. G. (Member), Central Cable Corporation, Jersey Shore, Pa.
Dorsey, J. R., B. F. Goodrich Company, Akron, Ohio.
Draper, C. A., United Broadcasting Company, Cleveland, Ohio.
Dusenbury, C., Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Easley, J. K., General Electric Company, Erie, Pa.
Eidell, R. H., Mack Manufacturing Corporation, Allentown, Pa.
Eichenberg, C. L., Bethlehem Steel Company, Bethlehem, Pa.
Engel, A., United States Navy Yard, Philadelphia, Pa.
Euler, F. J., Jr., Revere Copper and Brass Company, Baltimore, Md.
Evans, F. J., Duquesne Light Company, Pittsburgh, Pa.
Fahrnkopf, C. D., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Felver, R., Westinghouse Electric and Manufacturing Company, Mansfield, Ohio.
Fink, L., III, Bell Telephone Company of Pennsylvania, Philadelphia.
Frick, G. P., Brown Instrument Company, Philadelphia, Pa.
George, H. T., Edwin L. Wiegand Company, Pittsburgh, Pa.
Giles, W. F., Jr., Gas and Electric Company of Baltimore, Baltimore, Md.
Glass, E. W., General Chemical Company, North Claymont, Del.
Gorman, W. J., American Telephone and Telegraph Company, Philadelphia, Pa.
Gregg, W. E., Consolidated Gas, Electric Light and Power Company, Baltimore, Md.
Guilfoos, L. J., Carnegie Institute of Technology, Pittsburgh, Pa.
Harman, W. W., General Electric Company, Philadelphia, Pa.
Harper, J. A., Apex Hosiery Company, Philadelphia, Pa.
Heigle, W. W., The Ohio Power Company, Portsmouth.
Hendricks, A. W., Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Hood, H. C., Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Horn, F. C., Lima Electric Motor Company, Lima, Ohio.
Jankiewicz, E. J., Philadelphia Electric Company, Philadelphia, Pa.
Johnson, H. V., Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Johnson, L., Jr., Federal Power Commission, Washington, D. C.
Johnston, W. T., The Osborn Manufacturing Company, Cleveland, Ohio.
Jones, J. P., Ohio Edison Company, Springfield.
Kazan, L., care M. Kazan, Philadelphia, Pa.
Kennedy, T. F., Calvert Distilling Company, Relay, Md.
Koch, L. C., R. F. D. 1, Wapakoneta, Ohio.
Landefeld, H., Jr., Allis-Chalmers Manufacturing Company, Pittsburgh, Pa.

Lasswell, P. M., United States Air Corps, Wright Field, Dayton, Ohio.
Luce, J. R., Burke Electric Company, Erie, Pa.
Lytle, D. B., United States Chromium Company, Philadelphia, Pa.
Manning, E. C., Rural Electrification Administration, Washington, D. C.
Marx, C. J., Reliance Electric and Engineering Company, Cleveland, Ohio.
Meiklejohn, W. H., General Electric Company Erie, Pa.
Mendelson, S. I., Cleveland Electric Illuminating Company, Cleveland, Ohio.
Metz, L. P., Philadelphia Ordnance District of United States Army, Philadelphia, Pa.
Migdal, S., B. F. Goodrich Company, Akron, Ohio.
Miller, J. W., care John Barron, Washington, D. C.
Mitchell, D. H., Beach Erosion Board, War Department, Washington, D. C.
Monks, W. E., B. W. Cornelius, Consulting Engineer, Columbus, Ohio.
Moore, L. M. (Member), Rural Electrification Administration, Washington, D. C.
Moulton, C. W., Ohio Power Company, Portsmouth.
Nesbit, D. E., Pennsylvania Edison Company, Altoona.
Novak, S. T., Bailey Meter Company, Cleveland, Ohio.
Otterson, L. A., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Otto, W., 2413 Charles Street, N.S., Pittsburgh, Pa.
Parsons, E. H., Rural Electrification Administration, Washington, D. C.
Perry, D. J. (Member), Bell Telephone Company of Pennsylvania, Philadelphia.
Pfister, P. E., The Ohio Power Company, Coshocton.
Quashnock, E. J., Allis-Chalmers Company, Pittsburgh, Pa.
Rathbun, G. B., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Rea, W., Owens-Illinois Glass Company, Toledo, Ohio.
Renshaw, E. F., Rural Electrification Administration, Washington, D. C.
Rieman, S. T., Columbia Engineering Corporation, Cincinnati, Ohio.
Roehm, L. F., Pennsylvania Electric Company, Johnstown.
Rosenthal, B. R., Raphael Electric Company, Pittsburgh, Pa.
Sandberg, C. E., The Ohio Public Service Company, Ashland.
Sangster, H. L., Potomac Electric Power Company, Washington, D. C.
Schrawder, R. R., Armstrong Cork Company, Lancaster, Pa.
Sieber, F. C., 230 Harris Street, Harrisburg, Pa.
Siefert, W. A., Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Slifko, J. P., Babcock and Wilcox Company, Barberton, Ohio.
Smith, S. A., Chesapeake and Potomac Telephone Company, Washington, D. C.
Snyder, R. F., Goodyear Tire and Rubber Company, Akron, Ohio.
Springer, P. W., Columbus and Southern Ohio Electric Company, Athens, Ohio.
Steinkamp, A. T., Department of Public Utilities, City of Cincinnati, Ohio.
Stephens, D. S., Ohio Power Company, Philo.
Strong, R. M., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Swinehart, M. R., B. F. Goodrich Company, Akron, Ohio.
Tarzian, V., 3004 N. Howard Street, Philadelphia, Pa.
Thompson, E. A., Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Titus, C. H., Lehigh University, Bethlehem, Pa.
Toben, G. W., Procter and Gamble Company, St. Bernard, Ohio.
Tweeddale, A. L., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Undy, W. W. (Member), E. I. du Pont de Nemours and Company, Deepwater, N. J.
Watson, R. W., Carter Coal Company, Coalwood, W. Va.
Werner, C. J. (Member), General Motors Corporation, Dayton, Ohio.
Wingert, L. E., General Electric Company, Philadelphia, Pa.
Winters, H. M., United States Chromium Corporation, Wilkinsburg, Pa.
Woolard, S. B., General Electric Company, Philadelphia, Pa.
Wurdack, A. C., Jr., Line Material Company, Zanesville, Ohio.
Wurster, J. H., General Electric Company, Erie, Pa.

3. New York City

Adams, R. V., Westinghouse Electric and Manufacturing Company, Newark, N. J.
Allison, H. W., Bell Telephone Laboratories, Inc., New York, N. Y.
Anderson, R. E., Federal Shipbuilding and Drydock Company, Kearny, N. J.
Beatty, W. J., Metropolitan Life Insurance Company, New York, N. Y.
Bernard, R. W., Public Service Electric and Gas Company of New Jersey, Hackensack.
Britton, L. H. (Member), New Jersey Bell Telephone Company, Newark.
Calhoun, F. G., Sperry Products, Inc., Hoboken, N. J.
Cantone, R., American Standard Watch Company, Woodside, L. I., N. Y.
Cowperthwait, W. L., Jr., Bell Telephone Laboratories, New York, N. Y.
Doblmaier, A. H., Columbia University, New York, N. Y.
Farr, G. E., Scomet Engineering Company, Carteret, N. J.
Finkel, C. A., Okonite Company, Passaic, N. J.
Fox, J., Radio Television Institute, New York, N. Y.
Furbeck, A. R., E. I. du Pont de Nemours Company, Inc., Newark, N. J.
Gamey, W. A., Westinghouse Electric and Manufacturing Company, New York, N. Y.
Gemmill, F. Q., Sperry Gyroscope Company, Inc., Brooklyn, N. Y.
Gentili, A., 228 Bay 11 Street, Brooklyn, N. Y.
Gioia, J. A., 8636 Bay 16 Street, Brooklyn, N. Y.
Goldman, S., 121 Beach 87 Street, Rockaway Beach, N. Y.
Gough, T. A., Jr., American Can Company, Brooklyn, N. Y.
Grandolfi, J. A., Lionel Corporation, Irvington, N. J.
Guarino, F. J., 1528 West 5th Street, Brooklyn, N. Y.
Gumley, R. H., Bell Telephone Laboratories, Inc., New York, N. Y.
Ihmels, R. H., 383 Fairmount Avenue, Jersey City, N. J.
Indorf, H. J., 9 Roman Avenue, Forest Hills, N. Y.
Irby, C. W., Bell Telephone Laboratories, Inc., New York, N. Y.
Jacobson, L. J., AKWA Heaters, Inc., New York, N. Y.
Jaszczult, T. P., Westinghouse Electric and Manufacturing Company, Newark, N. J.
Johnson, H. W., New York Telephone Company, 101 Willoughby Street, Brooklyn, N. Y.
Joseph, W., Board of Transportation, New York, N. Y.
Kazarian, R., Bendix Aviation Corporation, Brooklyn, N. Y.
Kerby, G. A., care Fred M. Link, 125 West 17th Street, New York, N. Y.
Kittner, J. W., Bell Telephone Laboratories, Inc., New York, N. Y.
Klein, W., Consolidated Edison Company of New York, Inc., Flushing, N. Y.
Korn, A. (Member), Stevens Institute of Technology, Hoboken, N. J.
Kruger, E. K., 390 South Broadway, Lindenhurst, N. Y.
Lensner, H. W., Westinghouse Electric and Manufacturing Company, Newark, N. J.
Levinson, L. M., 6929 Failing Street, Arverne, N. Y.
Livant, I. J., Department of Water Supply, New York, N. Y.
Loonie, W. P., Jr., College of the City of New York, New York, N. Y.
Loughlin, B. D., Hazeltine Service Corporation, Little Neck, L. I., N. Y.
Marino, A. J., Cutler-Hammer, Inc., New York, N. Y.
Monell, F. B., Jr., Bell Telephone Laboratories, Inc., New York, N. Y.
Nistico, F., National Lead Company, Sayreville, N. J.
Olcott, B., Long Island Lighting Company, Roslyn Heights, L. I., N. Y.
Rotondi, H. C., New York Telephone Company, New York, N. Y.
Sarano, J., Sperry Products, Inc., Hoboken, N. J.
Sawyer, H. M. (Member), American Gas and Electric Company, New York, N. Y.
Smith, W. E., Bell Telephone Laboratories, Inc., New York, N. Y.
Taft, W. N., Consolidated Edison Company of New York, Inc., New York, N. Y.
Waldau, W., Newark College of Engineering, Newark, N. J.
Webb, E. L., Picker X-ray Corporation, 300 Fourth Avenue, New York, N. Y.
Webster, W. F., care Andersen and Mackenzie, 153 Mercer Street, New York, N. Y.
Weichbrod, J., Board of Transportation, New York, N. Y.

4. Southern

Baker, S. E., Jr., Trumbull Electric Manufacturing Company, Ludlow, Ky.
Barnes, L. B., Jr., Alabama Gas Company, Tuscaloosa.
Botts, E. O., Jr., Piedmont and Northern Railway, Charlotte, N. C.
Brennan, W. J., Girard Station, Phenix City, Ala.
Brown, A. M., Jr., Georgia Power Company, Augusta.
Bullock, J. B., Carolina Power and Light Company, Raleigh, N. C.
Evans, A. O. (Member), Louisiana Power and Light Company, West Monroe.
Fischer, M., Kentucky and West Virginia Power Company, Inc., Ashland, Ky.
Gillmore, W. K., Fort Barrancas, Fla.
Goodwin, W. A., Kentucky and West Virginia Power Company, Pikeville, Ky.
Gordon, H., Jr., Radio Station WRVA, Richmond, Va.
Grogan, T. J., Jr., Newcomb and Boyd, Atlanta, Ga.
Hammond, A. L., War Department, United States Engineers, Vicksburg, Miss.
Harker, J. D., Electric Motor and Repair Company, Columbia, S. C.
Howard, H., Jr., South Carolina State Highway Department, Columbia.
James, T. G., Jr., 304 East Washington, Greenwood, Miss.
Johnson, L. D., III, Virginia Electric and Power Company, Richmond.
Johnson, M. C., South Carolina Electric and Gas Company, Parr.
Johnson, P. M., Jr., Southern Electric Service Company, Greensboro, N. C.
Kennedy, S. L., Louisiana Power and Light Company, Algiers.
Lancaster, E. L., Jr., Mississippi Power and Light Company, Jackson.
Lasseter, J. A., Georgia Power Company, Atlanta.
Mahon, P. M., Seaboard Air Line Railway, John's Island, S. C.
Mason, J. T. (Member), Randolph Electric Membership Corporation, Asheboro, N. C.
McNeel, F. K., Mississippi Power and Light Company, Jackson, Miss.
Osborn, F. W., Newport News Shipbuilding and Dry Dock Company, Newport News, Va.
Ritchie, J. A., Virginia Electric and Power Company, Richmond.
Rockett, R., Southern Bell Telephone and Telegraph Company, Charlotte, N. C.
Sargent, H. B. (Member), Mississippi Power and Light Company, Jackson.
Schmidt, B. A., Ivy H. Smith Company, Jacksonville, Fla.
Shearon, J. R., Duke Power Company, Winston-Salem, N. C.
Slicer, J. S., Jr., Division of Highway Planning, Atlanta, Ga.
Sobert, R. J., Labadieville, La.
Sullivan, A. H., Jr., Electric Power Board of Chattanooga, Chattanooga, Tenn.
Therkelsen, E. B., Clemson Agricultural College, Clemson, S. C.
Wakefield, E. H., University of Tennessee, Knoxville.
Whipple, J. R., Gulf States Utilities Company, Lake Charles, La.
Wilder, H. P., Duke Power Company, Spencer, N. C.
Williams, C. H., Florida Power and Light Company, Miami.
Williams, R. E., Jr., Westinghouse Electric and Manufacturing Company, Birmingham, Ala.
Wirpio, C. I., Joseph E. Seagrams and Sons, Inc., Louisville, Ky.

5. Great Lakes

Alport, B. J., 6038 Kenmore, Chicago, Ill.
Anderson, A. W., Jr., Commonwealth Edison Company, Chicago, Ill.
Andrew, G. W., Howell Electric Motors Company, Howell, Mich.
Bassette, A. S., Bull Dog Electric Products Company, Detroit, Mich.
Bender, P. L., Goodman Manufacturing Company, Chicago, Ill.
Bentley, J. O., General Electric Company, Fort Wayne, Ind.
Bentley, L. J., General Motors Corporation, Detroit, Mich.
Boesewetter, W., 1334 North Marshall Street, Milwaukee, Wis.
Bunte, H., Commonwealth Edison Company, Chicago, Ill.
Bushman, S. F., Zenith Radio Corporation, Chicago, Ill.
Bychinsky, S. E., 1133 White Street, Ann Arbor, Mich.
Cahill, J. B., Tuttle and Kift, Inc., Chicago, Ill.
Cameron, W. D., General Electric Company, Detroit, Mich.
Cantalin, J. F., Fisher Body Corporation, Detroit, Mich.
Chevalley, E. A., General Motors Laboratories, Chicago, Ill.
Cleland, M. L., Interstate Power Company, Albert Lea, Minn.
Cline, A. D., New York Central Railroad, Detroit, Mich.
Cotton, J. H., Madison, Ind.
Daniel, E. J., Carnegie-Illinois Steel Company, Gary, Ind.
Eliasen, A. N. B., Minnesota Power and Light Company, Duluth.
Fisher, E. J., 831 East 46 Street, Chicago, Ill.
Ford, R. S., Control Corporation, Minneapolis, Minn.
Frank, R. L., Bull Dog Electric Products Company, Detroit, Mich.
Frederiksen, V., Jr., A. G. Redmond Company, Owosso, Mich.
Funk, J. R., Eagle Signal Corporation, Moline, Ill.
Gruver, V. W., Stanley Engineering Company, Muscatine, Iowa.
Harback, H. D., F. Mattern Manufacturing Company, Chicago, Ill.
Hass, J. R., Jr., Chicago, Milwaukee, St. Paul and Pacific Railroad Company, Milwaukee, Wis.
Hirsch, C. G., United States Army Engineers Corps, Mohawk, Mich.
Hoeper, H. B., General Motors Corporation, Detroit, Mich.
Homrighous, P. W., Jos. T. Ryerson and Son, Inc., Chicago, Ill.
Hopper, R. E., Minneapolis Honeywell Regulator Company, Minneapolis, Minn.
Jacobson, O. K., Graybar Electric Company, Minneapolis, Minn.
Johnson, G. S., Sunbeam Electric Manufacturing Company, Evansville, Indiana.
Julio, T., Youngstown Steet and Tube Company, Indiana Harbor, Ind.
Karger, D. W., International Harvester Company, Fort Wayne, Indiana.
Kelley, H. E., Interstate Power Company, Dubuque, Iowa.

Kwolek, M. J., Anaconda Wire and Cable Company, Marion, Ind.
Leissring, E. H., Wisconsin Electric Power Company, Milwaukee.
Lund, C. H., 515 Delaware Street, S. E. Minneapolis, Minn.
Malick, K. D., Allis-Chalmers Manufacturing Company, Milwaukee, Wis.
McCormack, J. B., Becker Brothers Carbon Company, Cicero, Ill.
Miller, O. B., Automatic Electric Company, Chicago, Ill.
Mizer, D. E., The Ready-Power Company, Detroit, Mich.
Mosher, W. J., Kalkaska, Mich.
Osborn, R. L., Webster Company, Chicago, Ill.
Osterberg, E. K., Carnegie-Illinois Steel Corporation, Gary, Ind.
Pilz, O. W., R. R. 1, Box 108 Wausau, Wis.
Premack, J., 1000 Russell Avenue, N., Minneapolis, Minn.
Richards, C. A., Radio Station WFBM, Indianapolis, Ind.
Rohrer, S. B., Western Union Telegraph Company, Chicago, Ill.
Schirf, R. F., Commonwealth Edison Company, Chicago, Ill.
Schnell, W. O., Commonwealth Edison Company, Chicago, Ill.
Servatzy, R. C. (Member), Commonwealth Edison Company, Chicago, Ill.
Slaughter, G. K., Electro-Motive Corporation, LaGrange, Ill.
Thompson, J. R., Langford Electric Company, Minneapolis, Minn.
Trebilcock, J. L., Fairbanks, Morse and Company, Chicago, Ill.
Van Horn, J. H., Automatic Electric Company, Chicago, Ill.
Warren, R. E., Indianapolis Power and Light Company, Indianapolis, Ind.
Warriner, R. R., Belmont Radio Corporation, Chicago, Ill.
Whitmoyer, I. W., Southern Indiana Gas and Electric Company, Evansville, Ind.
Wright, A. B., Howell Electric Motors Company, Howell, Mich.
Zeller, A. J., Public Service Company of Indiana, Brazil, Ind.
Zierjack, R. L., Western United Gas and Electric Company, Aurora, Ill.

6. North Central

Anderson, J. A., Jr., Public Service Company of Colorado, Denver.
Blake, A. F., Public Service Company of Colorado, Denver.
Dodrill, G. E., Interstate Power Company, O'Neill, Nebr.
Haynes, H. E., South Dakota School of Mines, Rapid City.
Howard, F. C., Iowa-Nebraska Light and Power Company, Lincoln, Nebr.
Johnson, P. H., Public Service Company of Colorado, Denver.
Liss, D. M., University of Denver, Denver, Colo.
Meyer, R. W., Public Service Company of Colorado, Denver.
Thomason, F., Bluff's Machinery and Supply Company, Scottsbluff, Nebr.
Williams, E. M., Rocky Mountain Engineering Company, Denver, Colo.

7. South West

Bradley, J. C., Gulf States Utilities Company, Beaumont, Tex.
Bysfield, F. E., Rocheport, Mo.
Cary, W. F., Arrow Drilling Company, Odessa, Tex.
Chappell, C. M., Jr., care Eilers, Schaumberg, Fischer, St. Louis, Mo.
Coon, R. M., Kansas Gas and Electric Company, Wichita.
Cravens, G. M., Magnolia Petroleum Company, Beaumont, Tex.
Dice, R. F., Kansas Gas and Electric Company, Wichita.
Dickson, R. C., Phelps Dodge Refining Corporation, El Paso, Tex.
Files, S. J., Jr., 910 East Main Street, Itasca, Tex.
Gutsch, F. L., El Paso Electric Company, El Paso, Tex.
Hall, D. L., Texas Pipe Line Company, Houston.
Houghton, R. B., Petty Geophysical Engineering Company, San Antonio, Tex.
Hulsey, B. B., Jr., Texas Electric Service Company, Fort Worth.
Jacobson, J., Inland Utilities Company, Scott City, Kans.
Kirkhuff, J. G., 2322 North Cross, Oklahoma City, Okla.
McHarg, A. H., Wagner Electric Corporation, St. Louis, Mo.
Peters, N. G., Century Electric Company, St. Louis, Mo.
Post, H. L., 328 Cypress St., Baytown, Tex.
Procter, W. S., Houston Lighting and Power Company, Houston, Tex.
Rittenhouse, J. W., James R. Kearney Corporation, St. Louis, Mo.
Sander, V. A., W. N. Matthews Corporation, St. Louis, Mo.
Sears, T. F., Allis-Chalmers Manufacturing Company, Tulsa, Okla.
Snyder, E. E., American Telephone and Telegraph Company, El Paso, Tex.
Thomas, C. H., Texas Electric Service Company, Forth Worth.
Traxler, J. G., Humble Oil and Refining Company, Baytown, Tex.
Wischmeyer, C. R., Rice Institute, Houston, Tex.

8. Pacific

Bennion, R. B., Pacific Gas and Electric Company, Stockton, Calif.
Best, G. R., General Electric Company, Los Angeles, Calif.
Burns, M. C., Standard Oil Company of California, Richmond.
Campbell, D. E., 433—3rd Avenue, Upland, Calif.
Cannon, J. K., Pacific Gas and Electric Company, Oakland, Calif.
Chard, R. J., Pacific Gas and Electric Company, San Francisco, Calif.
Coleman, C. B., Rheem Manufacturing Company, Richmond, Calif.
Connelly, R. B., Los Angeles Bureau of Power and Light, Baker, Calif.
Cox, L. L., Westinghouse Electric and Manufacturing Company, Emeryville, Calif.
Dietze, H. L., Bureau of Power and Light, Los Angeles, Calif.
Freedman, H. J., Twentieth Century Fox Film Corporation, Beverly Hills, Calif.
Hamm, C. T., Electrical Facilities, Inc., Emeryville, Calif.
Holland, J. E., Pacific Electric Manufacturing Corporation, San Francisco, Calif.
Isaac, E. L., Pacific Gas and Electric Company, Redding, Calif.
Knierim, R. V., 680—60 Street, Oakland, Calif.
Lubisich, P. G., Pacific Gas and Electric Company, San Francisco, Calif.
McKinlay, J. R., War Department, U. S. E. D., San Francisco, Calif.
Nichandros, G., Columbia Steel Company, Pittsburg, Calif.
Paulson, O. D., Pacific Gas and Electric Company, Fresno, Calif.
Peccolo, L. D., Southern California Edison Company, Ltd., Los Angeles, Calif.
Pettit, J. M., University of California, Berkeley.
Pichetto, P. B., War Department, San Francisco, Calif.
Procter, E. N., Westinghouse Electric and Manufacturing Company, Emeryville, Calif.
Redding, F. A., Southern California Edison Company, Ltd., Alhambra, Calif.
Stevens, J. F., Los Angeles Bureau of Power and Light, Los Angeles, Calif.
Strawn, G. A., 1509 Merriman Drive, Glendale, Calif.
Viller, F. B., Pacific Gas and Electric Company, Fresno, Calif.
Vollum, E. O., Bureau of Power and Light, Los Angeles, Calif.
Weinstein, J., United States Department of Agriculture, Los Angeles, Calif.

9. North West

Austin, L. H., Bonneville Power Administration, Portland, Ore.
Blair, M. L., Washington Water Power Company, Spokane.
Charters, C. R., 6305 South East 21st Avenue, Portland, Ore.
Collins, C. M., Utah Power and Light Company, Salt Lake City.
Conners, F. M., Montana Power Company, Great Falls.
Davis, K. I., Pacific Power and Light Company, Portland, Ore.
Dunstan, L. A., Seattle Transit System, Seattle, Wash.
Edstrom, J. E., Pacific Power and Light Company, Portland, Ore.
Fanning, L. G., Washington Water Power Company, Spokane.
Forman, R. E., Pacific Power and Light Company, Portland, Ore.
Gaffney, J. M., United States Bureau of Reclamation, Leavenworth, Wash.
Hart, R. J., Boeing Aircraft Company, Seattle, Wash.
Magnuson, H. O., Puget Sound Power and Light Company, Seattle, Wash.
McKay, W. G., W. 1412—11th Avenue, Spokane, Wash.
Mitchell, W. B., Idaho Power Company, Kuna.
Newman, R. J., Station KOAC, Corvallis, Ore.
Newsom, E. G., Seattle Transit System, Seattle, Wash.
Osterud, G. D., General Electric X-Ray Corporation, Seattle, Wash.
Parmelle, W. G., Jr., Pacific Power and Light Company, Walla Walla, Wash.
Pickett, F. L., The Bonneville Project, Portland, Ore.
Pletcher, C. N., Northwestern Electric Company, Portland, Ore.
Satre, W. J., Washington Water Power Company, Spokane.
Seymour, R. S., Bonneville Power Administration, Portland, Ore.
Shaeffer, L. R., Box 783, Wapato, Wash.
Spencer, G. A., Utah Power and Light Company, Provo.
Swanson, G. C., Idaho Power Company, Payette.
Warr, G. D., United States District Engineer, Portland, Ore.
Yorioka, U., 710 Lane Street, Seattle, Wash.

10. Canada

Bescoby, F. E. (Member), B. C. Electric Steam Generating Station, Vancouver, B. C.
Crookston, J. G. W., Canadian and General Finance Company, Ltd., Toronto, Ont.
Farmer, P. J., English Electric Company, St. Catharines, Ont.
Harvie, R. A., Canadian Westinghouse Company, Hamilton, Ont.
Hetherington, W. L., Standard Oil Company, Vancouver, B. C.
Hill, J. A., University of British Columbia, Vancouver.
Honan, T. J. (Member), New Toronto Public Utilities Commission, New Toronto, Ont.
Jones, J. E., Canadian General Electric Company Ltd., Peterboro, Ont.
Kewin, G. E. (Member), Hydro Electric Power Commission of Ontario, Toronto.
King, W. A., Calgary Power Company, Ltd., Seebe, Alberta.
Manson, D. M., Hydro Electric Power Commission of Ontario, Toronto.
McDowell, G. E., West Kootenay Power and Light Company, Ltd., Upper Bonnington Falls, B. C.
Monaghan, C., 10726—106 Street, Edmonton, Alberta.
Robinson, E. F. V., Provincial Government, Department of Public Works, Edmonton, Alberta.
Ross, J. H., Commonwealth Electric Corporation, Welland, Ont.
Slipp, J. G., Canadian General Electric Company, Peterboro, Ont.
Stiles, J. W., Hydro Electric Power Commission of Ontario, Toronto.

Total, United States and Canada, 435

Elsewhere

Atsan, N., Ministry of Communication, Ankara, Turkey.
Auten, J. R., Lago Oil and Transport Company, Ltd., Aruba, N. W. I.
Cabrera, R. H., Manrique 622, Habana, Cuba.
Condom Sastre, A., Universidad de la Habana, Vedado, Habana, Cuba.
Harrison, G. E., Messrs. Crompton Parkinson, Ltd., Chelmsford, Essex, England.
Kilgour, D. B., East Geduld Mines, Ltd., Springs, Transvaal, South Africa.
Menocal, S. G., Calle 6, #406, Vedado, Habana, Cuba.
Eckhoff, J., A/S National Industri, Oslo, Norway.
Sain, H. L., General Electric, S. A., Rio De Janeiro, Brazil.
Yamakawa, M. H., Oana Electric Manufacturing Company, Ltd., Tokyo, Japan.

Total, elsewhere, 10

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the addresses as they now appear on the Institute record. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Allen, Herbert J., Box 1726, Houston, Texas.
Arnold, Bruce A., Ramona, Okla.
Bronstein, Joseph L., 922 N. Church St., Richland Center, Wis.
Browning, Robert Lee, Jr., General Delivery, Mount Vernon, Mo.
Evans, David T., Box 194, Anyox, B. C., Can.
Hollifield, Ray, 5118 Milam St., Dallas, Texas.
O'Brien, Raymond C., Levack, Ont., Can.
Sheen, Ronald Guy, 1151 Logan St., Denver, Colo.
Shimp, Robert P., 3749 N. Gratz St., Pittsburgh, Pa.

9 Addresses Wanted